RULS-AD-1984-350
9/12/84

- letter to Judge re: EDC plant
- w/ EDC report on sewerage

Pgs. 69

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FILE NO.

RULS - AD - 1984 - 350

September 12, 1984

RECEIVED
SEP 13 1984
JUDGE SERPENTELLI'S CHAMBERS

The Honorable Eugene D. Serpentelli
Judge, Superior Court of New Jersey
Ocean County Courthouse
Toms River, NJ 08753

Re: Allan-Deane v. Bedminster, Dobbs v. Bedminster
Docket No.: L-36896-70 P.W. & L-28061-71 P.W.

Dear Judge Serpentelli:

As I believe Mr. Ferguson has informed you already, we experienced a slight delay in meeting the Court's required provision of the planning report with reference to the proposed expansion of the EDC plant to service the lower income housing (as well the market housing) due to the recent marriage of our water quality consultant.

Dr. Ferrara has returned from his honeymoon, completed his report, and it, along with Mr. Callahan's material, is enclosed for your review.

Regrettably, we received but two copies of the sketch plat showing the actual location of the expanded sewer treatment plant on land to be acquired from NJDOT. Rather than delay the transmission of the remaining material any longer, I am sending one copy of the map to you, and ordering other maps. I will send the maps to all counsel as soon as they are reproduced.

Thank you very much for you patience in this matter.

Sincerely,

Thomas J. Hall

TJH:te
Enclosure
Federal Express
cc: Alfred Ferguson, Esq.
Peter J. O'Conner, Esq.
George Raymond, P.P.
Donald Klein, Esq.
Kenneth Meiser, Esq.
Daniel F. O'Connell, Esq.

Environmental Disposal Corp.
P.O. BOX 509
PLUCKEMIN, N.J. 07978
201-234-0677

RECEIVED
SEP 13 1984

TO: The Honorable Eugene D. Serpentelli
Superior Court of New Jersey

FROM: Neil V. Callahan, President, Environmental Disposal Corp.

RE: Environmental Disposal Corp.'s Current Expansion Program

DATE: September 11, 1984

INTRODUCTION

Environmental Disposal Corp. (EDC) is a public sewerage utility with an existing franchise area that has been approved by municipal resolution in both Bedminster and Bernards Townships and approved by the New Jersey Board of Public Utilities (NJBPU). This franchise area covers the Southeastern portion of Bedminster and the South-western portion of Bernards. EDC's sole function is to provide safe and adequate sewage treatment service. To provide this service EDC has built and currently owns and operates one of the country's premier advanced wastewater treatment facility and collection system. The operation and discharge of this facility is closely monitored and reported to the New Jersey Department of Environmental Protection (NJDEP) to assure compliance with an NJDEP permit to operate and a NJPDES discharge permit. These facts are a testament to EDC's commitment to, and performance in providing sewage treatment service. EDC, based on its experience and all available information to date, remains confident that it can and will produce treatment facility capacity most expeditiously and efficiently.

DEFINING SERVICE "NEED"

EDC, subsequent to the completion and start-up of its existing treatment facility, apart from any initiative of Mount Laurel II proceeding, began evaluating and planning for the sewer service needs of all potential customers within its franchise area. EDC's efforts were hampered initially because sewer service "need" is a function of land use, and the land use for a majority of EDC's franchise area is currently being decided by Mount Laurel litigation pending before Superior Court Judge Eugene D. Serpentelli in Allan-Deane v. Bedminster and Hills Development Company v. Bernards. EDC, therefore, has elected to use as a basis for determining the potential service need in its Bedminster service area the recommendations of the Special Planning Master, George M. Raymond, who was appointed by Judge Serpentelli in Allan-Deane v. Bedminster. In Bernards, EDC has relied on information supplied by The Hills Development Company (HDC) as to its potential need. EDC has found that an expansion of treatment plant capacity to 1.75 MGD is needed to service its total franchise area and the area generically known as the AT&T tract.*

EDC, in the Bedminster portion of its service area and with the full expanded capacity available, will be able to provide service to approximately 4,100 dwelling units including 739 to 889 Mount Laurel units and approximately 950,000 square feet of commercial space.

*This area is being considered by EDC at the request of Bedminster Township.

EXPANSION PROGRAM DEVELOPMENT
WATER QUALITY ANALYSIS

EDC having established the "need" for service in its franchise area wanted to develop a viable scenario for an expansion program. EDC posed the following question: Using the same process as the existing treatment plant, a process recognized as "Best Available Technology, economically achievable" (BAT) for domestic wastewater, is there any insurmountable water quality problems with a 1.750 MGD discharge? To answer this question, EDC contracted for a water quality analysis at the expanded discharge rate. (Raymond A. Ferrara, PhD., Water Quality Impact Assessment for The Environmental Disposal Corp. Treatment Plant Expansion, September 1984) The Ferrara report finds that for the pollutants of major concern in evaluating wastewater treatment plant discharges, Biochemical Oxygen Demand (BOD), Suspended Solids, Ammonia-nitrogen, and Dissolved Oxygen there are no significant problems even under the most critical receiving water conditions. The Ferrara report does however, identify two parameters, Total Dissolved Solids (TDS) and Total Phosphorus (TP) in which there are identifiable changes in the concentration of these parameters during the most critical receiving water conditions. Ferrara was unable to determine the specific impacts, or the effect of these changes on the receiving water uses because of the limited duration of the period of concern under which the changes would occur, and because of the problem that predictive models for pollutants of normally lessor concern in wastewater discharges, such as TDS and TP, that can determine specific impacts are not generally applicable or available. Ferrara therefore has recommended that the expanded discharge be permitted with the condition that continuous ongoing evaluation of the receiving water quality be undertaken as a requirement of an expansion permit (EDC constructed its existing treatment facility with a similar condition.)

EXPANSION LAND ACQUISITION

Based on the positive water quality findings in the Ferrara report EDC began acquisition proceedings for the land identified as the primary site for a treatment plant expansion, Lot 1 Block 59A adjacent to the existing treatment facility. After vain efforts to try to locate correct property maps from the New Jersey Department of Transportation (NJDOT), the land owner, EDC opted to prepare a sketch plat of the parcels (T & M Associates, August 1984) so as not to delay the acquisition proceedings.

With the sketch plat complete EDC was able to commission the firm of Halpern and Davidson to determine the appraised value of the parcel. The present status of the discussions between EDC and NJDOT are that there is no identifiable obstacle to EDC's acquisition of the land.

There is in existance a proposed agreement regarding sewer service between Bedminster, EDC, and The Hills Development Company (HDC). A condition of this agreement is that the Township would be required to purchase the land from NJDOT and convey the land to EDC. This action would significally reduce the time required for acquisition of land by EDC.

PROPOSED FACILITIES

EDC is proposing to expand its treatment capacity to 1.75 MGD. EDC's proposal for providing this capacity consists of constructing two additional process trains of 0.9 MGD combined capacity on a five acre parcel of land adjacent to the present treatment plant site. Each of these two process trains would consist of unit operations similar, if not identical, to the existing Bardenpho operations. The treatment level provided by this plant is the maximum attainable by processes generally recognized as "Best Available Technology, economically achievable" (BAT) for domestic wastewater. The effluent from the expanded plant will be discharged to the same unnamed tributary of the Raritan River as the existing discharge.

FINAL IMPACT STATEMENT & APPLICATION DEVELOPMENT

EDC to conclude program development and to begin application has contracted with the International firm of Metcalf & Eddy, Inc. for the preparation of a final Environmental Impact Statement (EIS), a NJPDES permit application, and all professional services necessary to acquire a Discharge Allocation Certificate. The EIS and applications will be completed in October 1984. Upon submission of these materials EDC will have formally begun all approval processes necessary for a treatment plant expansion to 1.75 MGD.

Environmental Disposal Corp.

SCHEDULE FOR EXPANSION PROGRAM

The materials prepared for, and by EDC in its expansion program has been done at approximately the same schedule as was proposed in a report titled "Sewage Alternatives: Mount Laurel II Housing, Bedminster Township" by Neil V. Callahan, dated April 6, 1984. There remains no changes to that proposed schedule of forty-three months to have expanded capacity operational.

AGREEMENT
BETWEEN
ENVIRONMENTAL DISPOSAL CORPORATION
AND
METCALF & EDDY, INC.
FOR
PROFESSIONAL SERVICES

THIS AGREEMENT, made this 11 day of July, 1984, by and between ENVIRONMENTAL DISPOSAL CORPORATION, hereinafter called the "Client", and METCALF & EDDY, INC., with offices at 652 East Main Street, Bridgewater, New Jersey, hereinafter called the "Engineer".

WITNESSETH, for the considerations hereinafter set forth, the parties hereto agree as follows:

ARTICLE 1 - ENGAGEMENT OF THE ENGINEER

1.1 The Client hereby engages the Engineer and the Engineer hereby accepts the engagement to perform certain engineering services in connection with the application by the Client for a Discharge Allocation Certificate (DAC) from the New Jersey Department of Environmental Protection (NJDEP) to permit expansion of the Client's wastewater treatment plant, hereinafter called the "Project".

ARTICLE 2 - SERVICES OF THE ENGINEER

2.1 General

2.1.1 The Engineer will perform professional services in connection with the Project as hereinafter stated.

2.1.2 The Engineer will serve as the Client's professional engineering representative in those phases of the Project to which this Agreement applies and will consult with and advise the Client during the performance of his services.

2.2 Specific Services

The Engineer will perform the following:

2.2.1 Consult with the Client to determine the requirements of the Project.

2.2.2 If requested by the Client, conduct a pre-application conference between the NJDEP, the Client's representative, and the Engineer.

2.2.3 Review and furnish comments to the Client on the conclusions reached in the report Water Quality Impact Assessment for the EDC Treatment Plant Expansion, April, 1984 by R.A. Ferrara, Ph.D., as they pertain to the application for a DAC.

2.2.4 Prepare a draft engineering report for expanding the Client's wastewater treatment plant, from the present average daily flow rate of 0.85 million gallons per day to an average daily flow rate of 1.8 million gallons per day. The report will be based on expanding the Client's wastewater treatment plant with a parallel treatment train consisting of the same plant processes used in the existing plant. The Engineer will prepare a preliminary layout of the proposed facilities to be located on the site located adjacent to the Client's wastewater treatment plant site, which is currently owned by the New Jersey Department of Transportation.

2.2.5 Provide consultation and advice as to the necessity of providing or obtaining other services such as: property boundary, right-of-way, topographic and utility surveys; soil borings, probings or other subsurface explorations; other special consultation; and act as the Client's representative in connection with any such services.

2.2.6 Prepare a draft environmental assessmet statement (EAS) as a supplement to the DAC application. The EAS will incorporate the report <u>Water Quality Impact Assessment for the EDC Treatment Plant Expansion, April, 1984</u> by R.A. Ferrara, Ph.D. The EAS will also incorporate other available information pertinent to the project furnished by the Client, such as previous reports and any other data relative to the EAS.

2.2.7 Submit two copies of the draft DAC application and supplements (draft engineering report and draft EAS) to the Client for review.

2.2.8 Attend a meeting with the Client's representative to receive comments on the draft DAC application and supplements.

2.2.9 Revise the draft DAC application and supplements taking into consideration the Client's comments. Submit two copies of the final DAC application and supplements to the Client for submission to the NJDEP.

2.2.10 If requested by the Client, attend a post-application meeting with the NJDEP and the Client's representative to receive comments on the DAC application and supplements.

2.2.11 Revise the DAC application and supplements, if required by the NJDEP's comments, and furnish two copies of the revised documents to the Client for submission to NJDEP.

2.2.12 If requested by the Client, attend a public hearing to present the basis for the DAC application and to answer questions concerning the DAC application.

2.2.13 Revise the DAC application and supplements if required by the results of the public hearing and furnish two copies of the revised documents to the Client for submission to NJDEP.

ARTICLE 3 - RESPONSIBILITIES OF THE CLIENT

The Client without cost to the Engineer, will:

3.1 Place at the disposal of the Engineer all available information pertinent to the Project upon which the Engineer can rely, including previous reports and any other data relative to design and construction of the Project.

3.2 Provide access to and make all provisions for the Engineer to enter upon public and private lands as required for the Engineer to perform his work under this Agreement.

3.3 Designate in writing a person to act as the Client's representative with respect to the work to be performed under this Agreement, such person to have complete authority to transmit instructions, receive information, interpret and define the Client's policies and decisions with respect to materials, equipment elements and systems pertinent to the work covered by this Agreement.

3.4 Furnish the Engineer all needed property, boundary and right-of-way surveys.

ARTICLE 4 - PERIOD OF SERVICE

4.1 The Engineer shall proceed with the services under this Agreement promptly, after receiving authorization to proceed, and will diligently and faithfully prosecute the work to completion in accordance with applicable engineering standards.

4.2 The Engineer shall not be responsible for any delays in the performance of his services hereunder caused by strikes, action of the elements, acts of any government, civil disturbances, delays of the Client in supplying information and in approving material submitted by the Engineer, or any other cause beyond his reasonable control, or for the expenses or other direct or indirect costs or consequences arising from such delays.

ARTICLE 5 - PAYMENTS TO THE ENGINEER

5.1 For the services performed, the Client will pay the Engineer on a time-charge plus expense basis, monthly as charges accrue, the sum of the following:

5.1.1 Salary cost times a multiplier of 2.25.

5.1.2 A laboratory surcharge of $4.00 for each man-hour of laboratory time chargeable to the project.

5.1.3 Nonsalary expenses times a multiplier of 1.10.

5.2 Salary cost is defined as salary and wages paid to personnel for time chargeable to the Project plus a percentage covering the cost of the Engineer's statutory and customary benefits, such as insurance, sick leave, holidays, vacations, bonuses, medical and retirement benefits, etc.

5.3 Nonsalary expenses include such typical expenses as cost of: transportation and subsistence; toll telephone calls and telegraph; printing and reproduction; computer time and programming costs; word processing; identifiable supplies; outside consultant charges; subcontracts for services such as surveys, subsurface investigations, and testing by commercial laboratories; and charges by reviewing authorities.

5.4 In the event payment to the Engineer is delayed beyond 60 days from the date of the Engineer's invoice, the Engineer shall receive interest at the current prime rate of the Chase Manhattan Bank plus one percent, per annum, on the unpaid balance from said sixtieth day, subject to state limitations on maximum interest rates.

ARTICLE 6 - GENERAL PROVISIONS

6.1 <u>Litigation and Additional Work</u>

In the event Engineer is to prepare for or appear in any litigation in behalf of the Client or is to make investigations or reports on matters not covered by this Agreement, or is to perform additional work due to changes in codes or regulations issued by any regulatory agency after execution of this Agreement, or is to perform other services not included herein, additional compensation shall be paid the Engineer as is mutually agreed upon.

IN WITNESS WHEREOF, the parties hereto have executed this Agreement as of the day and year first above stated.

ENVIRONMENTAL DISPOSAL CORPORATION
PLUCKEMIN, NEW JERSEY

By: ______________________
Neil Callahan
Title: President

ACCEPTED AND AGREED:
METCALF & EDDY, INC.

By: ______________________
Allan Jacobs
Title: Vice President

DTS ~~EDS~~ EDS - 11/5/84

raymond a. ferrara, ph.d.

WATER QUALITY IMPACT ASSESSMENT FOR THE ENVIRONMENTAL DISPOSAL CORPORATION TREATMENT PLANT EXPANSION

SEPTEMBER, 1984

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1. Introduction

The Environmental Disposal Corporation (EDC) operates an advanced wastewater treatment facility located in Bedminster Township, Somerset County, New Jersey. The treatment unit processes include the Bardenpho-Carrousel system, clarification, dual media filtration, disinfection and post-aeration. Effluent is discharged to an unnamed tributary to the North Branch Raritan River as illustrated in Figure 1. Both the tributary and the North Branch in this area are classifed FW2.N. EDC's effluent limitations as specified in NJPDES Permit No. NJ 0033995, effective date June 2, 1984, are presented in Table 1.

The treatment plant was constructed to provide sewer service for anticipated growth as well as existing residential and commercial establishments within Pluckemin Village. As a result of recent court decrees, anticipated growth within EDC's franchise area will be substantially greater than that originally conceived. Wastewater flow rate will consequently exceed the current effluent limitation of 850,000 gpd. A revised estimate is presented in Table 2. No net increase was provided for Pluckemin Village in Table 2 due to our inability to project its growth patterns. However, it is conceivable that an additional 50,000 gpd may be generated in future years. This would bring the total projected wastewater flow rate within the EDC franchise area to 1,750,000 gpd.

This report has been prepared to evaluate the receiving water quality impact associated with an expansion of the EDC treatment facility to satisfy this projected wastewater service requirement.

Figure 1. Environmental Disposal Corporation Treatment Plant Location. (USGS Gladstone Quadrangle)

*Treatment Plant Site

Table 1

Environmental Disposal Corporation Effluent Limitations
(NJPDES Permit No. NJ 0033995)

Parameter		Value
Effluent Flow Rate	30 day average	$\leq$ 0.85 mgd
BOD_5	30 day average	$\leq$ 32 kg/day and $\leq$ 10 mg/ℓ[1]
BOD_5	7 day average	$\leq$ 48 kg/day and $\leq$ 15 mg/ℓ[1]
BOD_5	30 day average	$\geq$ 96% removal[1]
SS	30 day average	$\leq$ 32 kg/day and $\leq$ 10 mg/ℓ[2]
SS	7 day average	$\leq$ 48 kg/day and $\leq$ 15 mg/ℓ[2]
SS	30 day average	$\geq$ 96% removal[2]
Fecal Coliform	30 day geometric mean	$\leq$ 200 per 100 mℓ[3]
Fecal Coliform	7 day geometric mean	$\leq$ 400 per 100 mℓ[3]
TDS	30 day average	$\leq$ 500 mg/ℓ[4]
TDS	7 day average	$\leq$ 750 mg/ℓ[4]
DO	7 day average	$\geq$ 6 mg/ℓ
Phosphorus as P*	30 day average	$\leq$ 0.5 mg/ℓ[5]
Phosphorus as P*	7 day average	$\leq$ 0.75 mg/ℓ[5]
Ammonia as N*	30 day average	$\leq$ 0.5 mg/ℓ[6]
Ammonia as N*	7 day average	$\leq$ 0.75 mg/ℓ[6]
Nitrate as N*	30 day average	$\leq$ 2.0 mg/ℓ[7]
Nitrate as N*	7 day average	$\leq$ 3.0 mg/ℓ[7]
pH	at all times	$6.0 \leq pH \leq 9.0$

[1,2,3,4,5,6,7] whichever is more stringent

*May 1 to October 1

Table 2

Projected Wastewater Generation Rates*
(per N. Callahan, April 3, 1984)

	Prior Projection (gpd)	New Projection (gpd)	Net Increase (gpd)
Bedminster Township			
PUD	241,313	241,313	0
Commercial	43,750	43,750	0
Highlands	103,125	187,500	84,375
Subtotal HDC Bedminster	388,188	472,563	84,375
Pluckemin Village	27,500	27,500	0
Site I	0	48,500	48,500
Site J (Ellsworth)	132,750	132,750	0
Site L (Sudler)	0	33,200	33,200
Ray Tract	30,000	30,000	0
Zimmerland Tract	0	23,500	23,500
Site N (Johnson)	0	22,700	22,700
City Federal	22,500	22,500	0
DOT Maintenance	0	4,000	4,000
O'Connell	0	7,500	7,500
	212,750	352,150	139,400
Subtotal Bedminster	600,938	824,713	223,775
Bernards			
Residential	227,475	843,750	616,275
Commercial	6,250	6,250	0
School	10,000	20,000	10,000
Subtotal HDC Bernards	243,725	870,000	626,275
Total	844,663	1,694,713	850,050

*Projections are based upon an average occupancy of 2.5 persons per dwelling unit and a per capita flow rate of 75 gpd. Commercial contributions are based upon a value of 0.125 gpd per square foot of floor space.

2. Water Quality Impact Assessment

2.1 Background

Any discharge of pollutants will to a certain extent alter some chemical concentrations of various constituents in a receiving water. Where water quality of the discharge is better than the natural background receiving water quality, those concentrations will be decreased which in most cases is a positive effect. In general however, even for highly treated wastewater discharges, the concentrations of certain constitutents will be greater in the discharge than in the receiving water. The net effect is therefore an increase in concentration above the ambient background condition for these constitutents. This effect may be positive, neutral, or negative depending on receiving water uses. The approach normally taken in evaluating water quality impacts associated with wastewater discharges has been to estimate the changes in receiving water concentrations for particular chemical constituents, and also to assess the impact of these changes to receiving water uses. The two of course are closely related. However the emphasis of the analysis is to identify the degree of change in chemical concentrations within which the appropriate receiving water uses are still maintained. The conclusion of such an analysis is to identify the acceptable changes in chemical concentrations which do not preclude prescribed water uses, i.e. *no impact to use.*

This approach has been utilized in a consistent fashion by regulatory agencies in determining effluent limitations for the EDC treatment plant. The currently permitted effluent limitations therefore provide one set of acceptable discharge characteristics which have been determined to result in no anticipated significant impact to receiving water uses. To guarantee that this anticipated condition of no significant impact will actually be achieved, a strict water quality monitoring program has been prescribed as part of the EDC permit. The first phase of that effort included a baseline stream monitoring program which has recently been completed (Environmental Modeling and Analysis, 1983). Continued water quality monitoring during the initial and subsequent years of operation of this facility will provide additional information on receiving water quality over a range of wastewater discharge flow rates. This approach of establishing a "before and after" water quality data base for verification of the theoretically calculated impact provides a prudent and cautious method of determining and updating wastewater discharge effluent limitations.

The set of water quality constituents which are of importance in evaluating the impact of a wastewater discharge originating from primarily residential sources includes dissolved oxygen (DO), the nutrients nitrogen (N) and phosphorus (P), total dissolved solids (TDS), suspended solids (SS), fecal coliform (FC), and pH. For the later three, it is clear that there will be no adverse impact. Table 3 provides a comparison of current natural background conditions,FW2.N water quality standards and the EDC effluent limitations. Conditions for the tributary and North Branch Raritan are as defined in the Basline Stream Monitoring Program. Data from this program for fecal coliform were not sufficient to establish a definitive background concentration. However, previous data suggest a value of about 100 per 100 ml (CDM/Resource Analysis, March, 1979). The EDC effluent limitations for SS, FC, and pH are

Table 3

Comparison of Water Quality Characteristics

	Tributary	North Branch Raritan River	FW2.N Water Quality Standard	EDC Effluent Limitation
SS (mg/ℓ)	110.	5.4	40	10
FC (no. per 100 mℓ)	---	---	200	200
pH (standard units)	7.2	7.3	6.5 - 8.5	6.0 - 9.0

consistent with the FW2.N water quality standards. Therefore in terms of these three constituents, no adverse impact to intended uses of these receiving waters is anticipated regardless of EDC's discharge flow rate. Therefore, no analysis will be conducted in this report for these three constituents, and the remainder of this effort will focus on potential impacts to dissolved oxygen, nitrogen, phosphorus, and total dissolved solids.

2.2 Hydraulic and Flow Rate Relationships

In order to complete a water quality impact assessment it is necessary to define the hydraulic characteristics of the receiving waters in question. These characteristics are important in that they control the degree of dilution, rate of transport, and the values of certain reaction rate coefficients. Hence, hydraulic characteristics are a key element in assessing waste assimilative capacity in a stream.

Hydraulic characteristics for the tributary have been identified in a previous report (Ferrara, 1982). Table 4 provides data on the flow frequency characteristics of the tributary. The MA7CD10 (minimum average seven consecutive day low flow which occurs once every ten years) was identified as 0.029 at the EDC outfall and 0.051 at the North Branch. As is typically the case, the MA7CD10 occurs less than one percent of the time. Average flows are an order of magnitude greater than the MA7CD10.

Manning's equation is used to relate stream characteristics to velocity and flow rate under uniform flow conditions. For a rectangular cross section, the equation may be written as follows:

Table 4

Flow Frequency in Unnamed Tributary

Flow Frequency*	Flow (cfs) in Tributary at EDC Outfall	Flow (cfs) in Tributary at North Branch
99%	0.036	0.063
98%	0.052	0.091
95%	0.066	0.12
90%	0.089	0.16
80%	0.14	0.25
70%	0.20	0.36
60%	0.28	0.49
50%	0.35	0.62

*99%, etc. indicates percent of time flow exceeds the value indicated in the table.

$$Q = \frac{1.49}{n} W H \left(\frac{WH}{W+2H}\right)^{2/3} S^{1/2} \qquad (1)$$

where Q = stream flow rate (cfs),

n = roughness coefficient,

W = channel width (ft),

H = channel depth (ft), and

S = channel slope (dimensionless).

The tributary characteristics are $n = 0.07$, $W = 6$ ft, and $S = 0.012$. Therefore at any given flow rate, equation (1) may be solved for the corresponding uniform flow depth. Since the tributary is characterized by a series of pools and uniform flow sections, the average depth, $\overline{H}$, over its entire length is somewhat higher than the theoretically calculated uniform flow depth, H. Ferrara (1982) concluded the following relationship

$$\overline{H} = 3H \qquad (2)$$

and therefore

$$\overline{U} = \frac{Q}{\overline{H}W} \qquad (3)$$

where $\overline{U}$ is the average velocity over the entire length of the tributary. Therefore, $\overline{U}$ will be equal to one-third of the uniform flow velocity, U.

Flow data on the North Branch Raritan River is collected at two gauging stations: at Far Hills and at Raritan. Watershed drainage areas for each of these stations are 26.2 and 190 square miles respectively. In the vicinity of the EDC treatment facility, the North Branch watershed totals 51.3 square miles. Flow rates at this location may be estimated by the following relationship:

$$Q = \alpha A^{\beta} \tag{4}$$

where A = the watershed drainage area, and α and β are constants. From the data collected at Far Hills and Raritan α and β can be calculated for any flow frequency value. This equation has been utilized to generate the data of Table 5. Note the consistency in values for β (range 0.80 - 0.87) and the constant increase in α for decreasing flow frequencies. In CDM/Resource Anlaysis (1979a), the MA7CD10 was identified as 6.3 cfs and given by the following

$$Q = 0.29\ A^{0.78} \tag{5}$$

again demonstrating consistency with the values of Table 5. As in the tributary, the MA7CD10 occurs less than one percent of the time, and is approximately an order of magnitude less than the average flow rate.

Manning's equation was again used to determine stream depths at various flow rates. The following stream characteristics were assumed:

W = 50 ft as used previously by CDM/Resource Analysis, 1979a

S = 0.001 measured from the USGS topographic map as the average stream slope between Route 206 and Burnt Mill Road

n = 0.055 a conservative value descriptive of a natural stream, winding, some pools and shoals, lower stages.

NJDEP (1976) conducted a dissolved oxygen modeling analysis on the North Branch Raritan and for the sections of concern to this report the following characteristics were assumed:

Table 5

Flow Frequency in North Branch Raritan River

Flow Frequency	Flow (cfs) at Far Hills	Flow (cfs) at Raritan	α	β	Flow (cfs) at EDC
99%	4.2	20.4	0.30	0.80	7.15
98%	5.3	26.9	0.37	0.82	9.21
95%	7.2	39.2	0.44	0.86	12.8
90%	9.7	52.5	0.60	0.85	17.2
80%	15.7	85.1	0.97	0.85	27.9
70%	19.9	109.	1.20	0.86	35.4
60%	26.3	148.	1.52	0.87	47.2
50%	32.6	182.	1.91	0.87	58.4

Q(cfs)	H(ft)	U(fps)
12-13	0.5-0.8	0.16-0.34
41	0.82-1.06	0.48-0.70

At corresponding flows and the stream characteristics cited above, Manning's equation predicts:

Q(cfs)	H(ft)	U(fps)
12	0.47	0.51
13	0.49	0.53
41	0.98	0.82

Predicted depths correspond well with those of NJDEP (1976) but velocities are considerably higher. This will be significant for the computation of certain reaction rate coefficients such as the reaeration rate coefficient. To provide a more conservative estimate an approach similar to that taken in the tributary was used. It was assumed that the average depth is twice the uniform flow depth, and therefore the average velocity would be one-half of the uniform flow velocity. In this case:

Q(cfs)	$\bar{H}$(ft)	$\bar{U}$(fps)
12	0.94	0.26
13	0.98	0.26
41	1.98	0.41

Average depth and velocity under this assumption are shown to be conservative estimates relative to the NJDEP (1976) values.

2.3 Dissolved Oxygen

As with any wastewater discharge containing organic and ammonia compounds, a primary concern with respect to receivng water quality impact is that related to dissolved oxygen depression. FW2.N water quality standards require that the dissolved oxygen concentration have a 24 hour average not less than 5.0 mg/ℓ.

For this study, a mathematical model based on the classical one-dimensional steady state BOD-DO equations for streams was utilized. The computer code is one originally developed by Hydroscience, Inc. for the Delaware River Basin Commission. The governing differential equations are as follows:

$$\frac{\partial L}{\partial t} = 0 = - U \frac{\partial L}{\partial x} - K_r L \qquad (6)$$

$$\frac{\partial N}{\partial t} = 0 = - U \frac{\partial N}{\partial x} - K_n N \qquad (7)$$

$$\frac{\partial D}{\partial t} = 0 = - U \frac{\partial D}{\partial x} - K_a D + K_d L + K_n N - P + R + S \qquad (8)$$

where L = CBOD $[M/L^3]$

N = NBOD $[M/L^3]$

D = DO deficit $[M/L^3]$

U = velocity $[L/T]$

t = time $[T]$

x = distance $[L]$

K_r = overall CBOD in-stream removal rate coefficient $[T^{-1}]$

K_d = CBOD deoxygenation rate coefficient $[T^{-1}]$

K_n = overall NBOD in-stream removal rate coefficient $[T^{-1}]$

K_a = reaeration rate coefficient $[T^{-1}]$

P = photosynthetic oxygen production rate $[M/L^3\text{-}T]$

R = algal respiration rate $[M/L^3\text{-}T]$

S = benthal oxygen demand rate $[M/L^3\text{-}T]$

The solution equations are:

$$L_x = L_0 \exp(-K_r \frac{x}{U}) \qquad (9)$$

$$N_x = N_0 \exp(-K_n \frac{x}{u}) \qquad (10)$$

$$D_x = D_0 \exp\left(-\frac{K_a x}{U}\right) + L_0 \frac{K_d}{K_a - K_r} \left[\exp(-K_r \frac{x}{U}) - \exp(-K_a \frac{x}{U})\right]$$

$$+ N_0 \frac{K_n}{K_a - K_n} \left[\exp(-K_n \frac{x}{U}) - \exp(-K_a \frac{x}{U})\right]$$

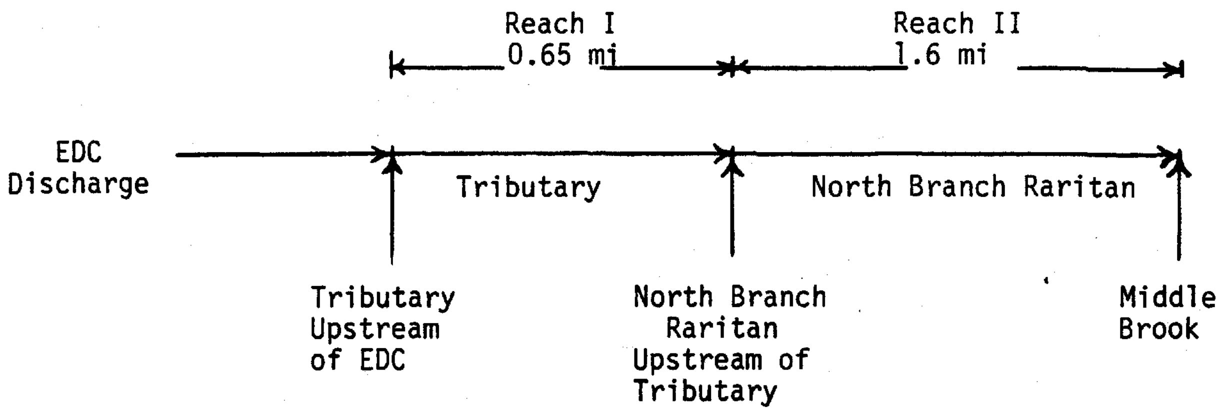
$$+ \frac{(R + S - P)}{K_a} \left[1 - \exp(-K_a \frac{x}{U})\right] \qquad (11)$$

where L_x, L_0 = CBOD at any location x and at x = 0, respectively

N_x, N_0 = NBOD at any location x and at x = 0, respectively

D_x, D_0 = DO deficit at any location x and at x = 0, respectively

The model was applied to the tributary from the point of the EDC discharge down to the confluence with the North Branch Raritan, and then along the North Branch to its confluence with Middle Brook. The system can be viewed as a linear network of two reaches as follows:



Upstream concentrations in the tributary and the North Branch were obtained from the Baseline Stream Monitoring Program, and EDC discharge concentrations were assumed equal to the current permit effluent limitations as follows:

	BOD_5	$CBOD_u$	$NBOD_u$	DO
EDC	10.	15.	2.29	6.0
Tributary Upstream	2.09	3.14	2.42	saturation
North Branch	1.92	2.88	2.06	saturation

MA7CD10 values of 0.03 and 6.3 cfs were assigned to the upstream tributary and upstream North Branch, respectively. An EDC discharge rate of 1.75 mgd (2.71 cfs) was stipulated consistent with the anticipated growth scenario presented in Section 1 of this report.

Reaction rate coefficients were chosen from established procedures as had been done in previous studies related to this discharge (CDM/Resource Analysis, 1979a; Ferrara, 1982). The reaeration rate coefficient is determined by the method of Covar (Figure 2). The appro-

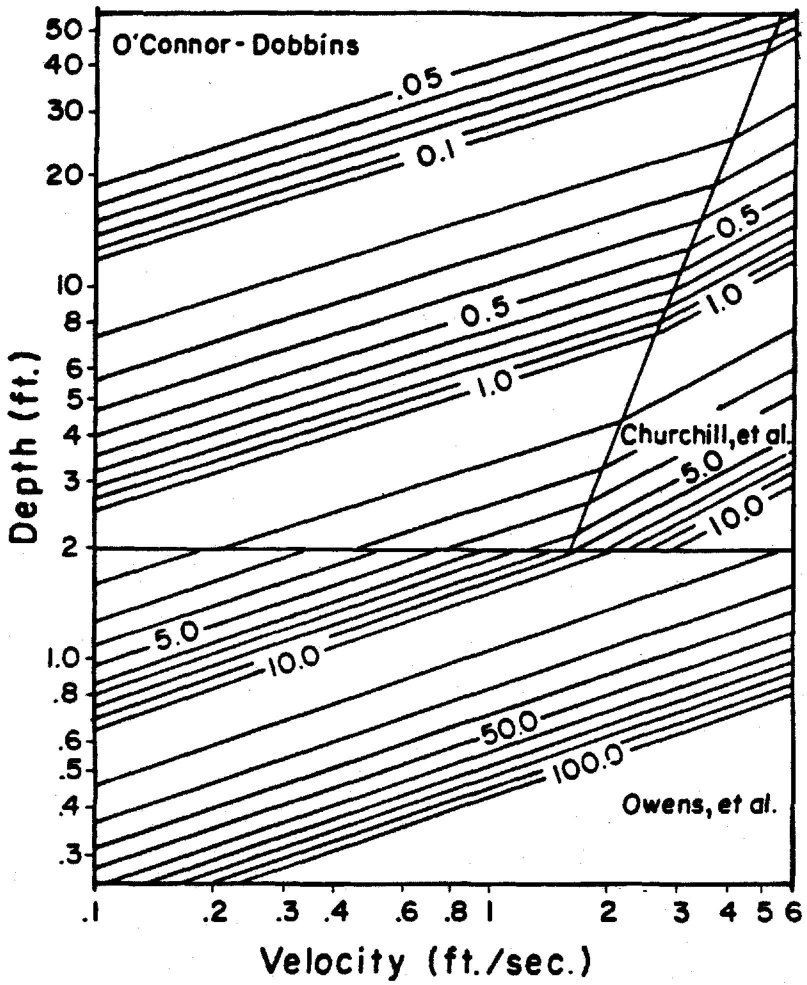


Figure 2. k_a vs. depth and velocity using the suggested method of Covar (1976).

priate equations for each of the three regions in Figure 2 are:

O'Connor-Dobbins $$K_a = 12.9 \frac{U^{0.5}}{H^{1.5}} \quad (12)$$

Owens, et. al. $$K_a = 21.7 \frac{U^{0.67}}{H^{1.85}} \quad (13)$$

Churchill, et. al. $$K_a = 11.6 \frac{U^{0.97}}{H^{1.67}} \quad (14)$$

where K_a = the reaeration rate coefficient, (day^{-1})

U = stream velocity, (fps)

H = stream depth, (ft)

Application of Manning's equation at the flow rates cited above gives: $\overline{H}$ = 1.2 feet and $\overline{U}$ = 0.39 fps in the tributary Reach I and $\overline{H}$ = 0.79 feet and $\overline{U}$ = 0.23 fps in the North Branch Reach II. Calculated values for K_a are therefore 8.4 and 12.5 day^{-1} respectively at 20°C. K_a is corrected in the model for temperature according to the following:

$$K_{a_T} = K_{a_{20}} (1.024)^{(T-20)} \quad (15)$$

The CBOD in-stream decay rate coefficient, K_r, and the CBOD deoxygenation rate coefficient, K_d, may be assumed to be equal since the pollutant input is essentially one hundred percent soluble. The decay rate coefficient is determined from Figure 3 to be 0.7 day^{-1} in Reach I and 0.8 day^{-1} in Reach II at 20°C. As a conservative assump-

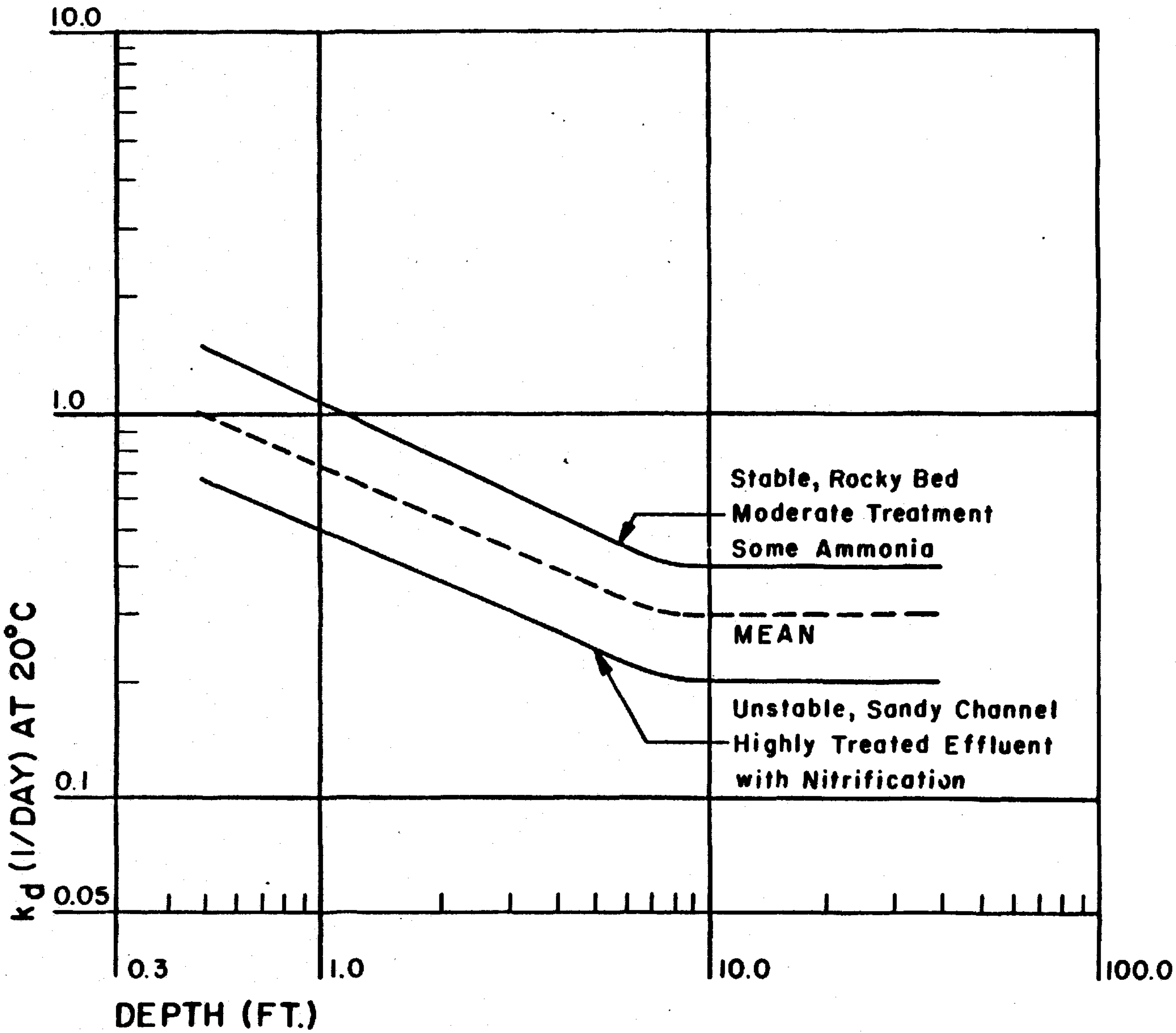


Figure 3. Deoxygenation Coefficient as a Function of Depth.

(after Hydroscience, 1971)

raymond a. ferrara, ph.d.

tion, K_n, the NBOD decay rate coefficient, was set equal to K_d, K_n is typically smaller than K_d, and assuming they are equal provides a greater stress on DO resources in the stream. These three reaction rate coefficients are corrected in the model for temperature according to the following

$$K_T = K_{20}(1.047)^{(T-20)} \tag{16}$$

Finally it was assumed that the sum of R + S - P is equal to zero.

The model output is presented in Appendix I. The EDC discharge accounts for nearly all the flow in the tributary. Because of shallow depth and steep slope leading to a swift velocity, aeration dominates deoxygenation. The assimilation ratio, $\theta = \frac{K_a}{K_d}$, is calculated to be 12.0 in the tributary and 15.7 in the North Branch. This is consistent with expected values as indicated in Figure 4. The maximum dissolved oxygen deficit, D_c, in each reach occurs at the start of the reach. This is true whenever $\frac{K_a}{K_d} > \frac{L_o}{D_o} + 1$, which is the case in both reaches. Under these conditions, it is clearly demonstrated that impacts to dissolved oxygen resources are minimal. This conclusion is consistent with those of previous studies (CDM/Resources Analysis, 1979a, 1979b; Ferrara, 1982).

To further demonstrate the dominance of aeration over deoxygenation in this system, a further test was made in which the model was arbitrarily run with K_a = 5.0 day^{-1} and $K_r = K_d = K_n$ = 1.0 day^{-1}. The results are demonstrated in Appendix II and show that even under this extreme condition, the minimum dissolved oxygen concentration in the North Branch Raritan is calculated to be 7.1 mg/ℓ, well above the water quality standard.

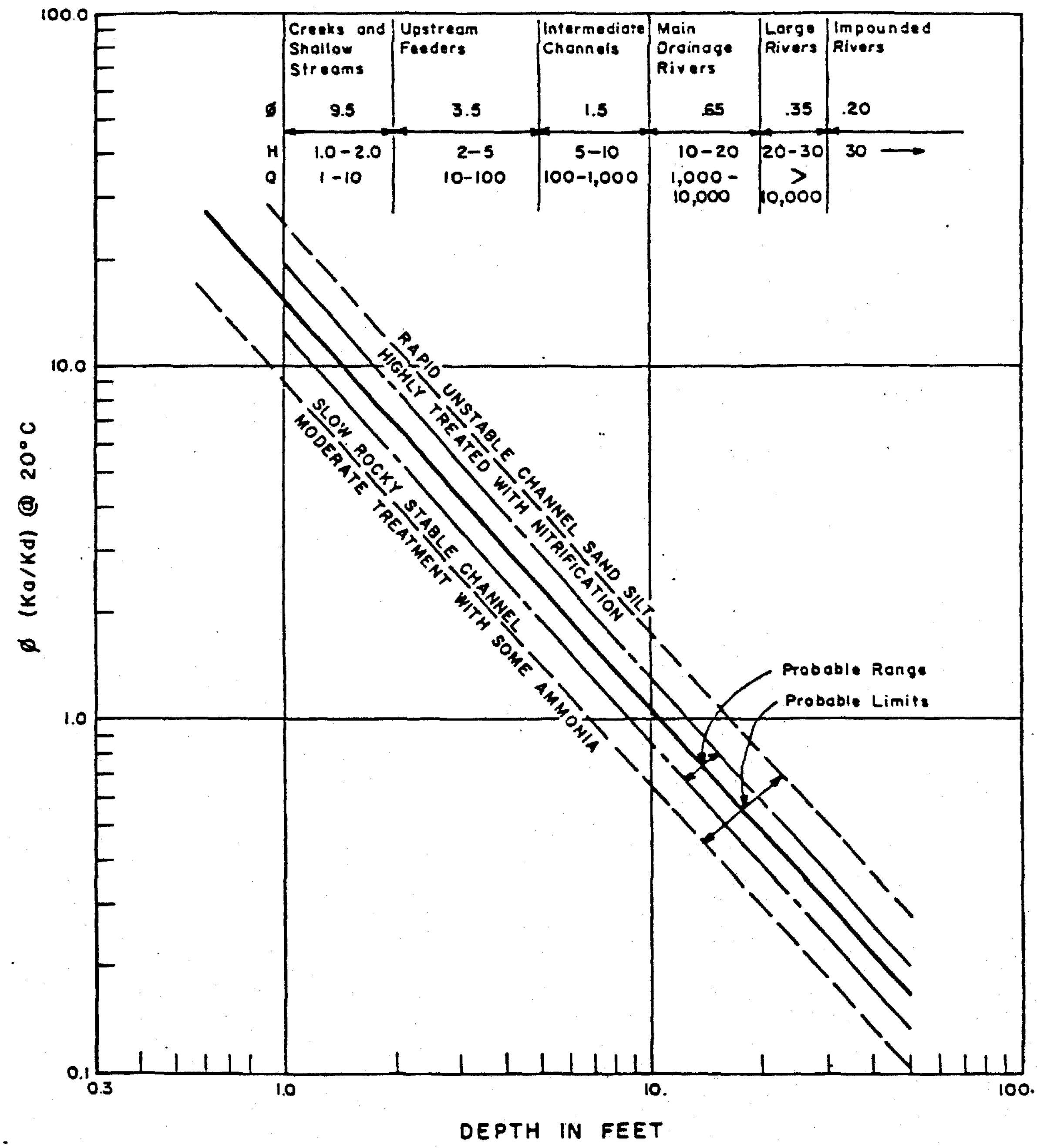


Figure 4
ASSIMILATION RATIO (Ø) AS
A FUNCTION OF DEPTH
(after Hydroscience, 1971)

In conclusion, because of the shallow nature of these receiving waters and the high level of treatment afforded the EDC wastewater, dissolved oxygen depletion is not calculated to be a problem.

2.4 Total Dissolved Solids

FW2.N water quality standards for total dissolved solids, TDS, require that concentrations not exceed 500 mg/ℓ or 133% of background, whichever is less, but the department (i.e. New Jersey Department of Environmental Protection) may authorize exceptions. The 500 mg/ℓ standard is derived from the maximum Drinking Water Standards. The 133% standard relates to minimizing changes in osmotic pressures which results in stresses to osmoregulatory capacity of higher trophic level aquatic organisms. Clearly, all species of fish and other aquatic organisms must tolerate a range of TDS concentrations to survive under natural conditions. It is well-known that TDS concentration in streams tends to be inversely proportional to flow rate. A classic example of this is the Passaic River as presented in Figure 5. CDM/Resource Analysis (1979c) completed a similar analysis for the North Branch Raritan River in the vicinity of the EDC treatment plant and found the following relationship:

$$TDS = 225\ Q_{NB}^{-0.152} \qquad (17)$$

where TDS = total dissolved solids concentration in the North Branch (mg/ℓ)

Q_{NB} = flow rate in the North Branch near the EDC facility (cfs)

Solution of this equation at the MA7CD10 of 6.3 cfs gives TDS = 170 mg/ℓ. At the 50% frequency flow rate of 58 cfs, TDS = 121 mg/ℓ. Hence any definition of background concentration requires specification of a flow rate also. At the MA7CD10 equation (17) predicts a 40% increase above the calculated background concentration at the 50% frequency flow. Indeed the EDC Baseline Stream Monitoring Program (Environmental Modeling and Analysis, 1983) conducted between January and July 1983, demonstrated ranges of 55 to 390 mg/ℓ and 72 to 171 mg/ℓ for the unnamed tributary and the North Branch Raritan, respectively. These ranges correspond to maximum observed values which are 709% and 238% respectively, of the minimum observed during a single seven month period. Extended monitoring is likely to reveal an even wider range. In light of this, it is apparent that an absolute standard which requires that concentrations not be increased more than 133% above "background" is indeed nebulous.

The currently permitted effluent limitations allow a TDS discharge concentration not to exceed 500 mg/ℓ. This value was determined during the early stages of this treatment facility's planning when a direct discharge to the North Branch Raritan River was proposed. A mass balance calculation was performed as follows:

$$TDS_d = \frac{(TDS_u \cdot Q_u) + (TDS_E \cdot Q_E)}{(Q_u + Q_E)} \qquad (18)$$

where TDS_d = resulting TDS concentration in the North Branch downstream of the EDC discharge, (mg/ℓ)

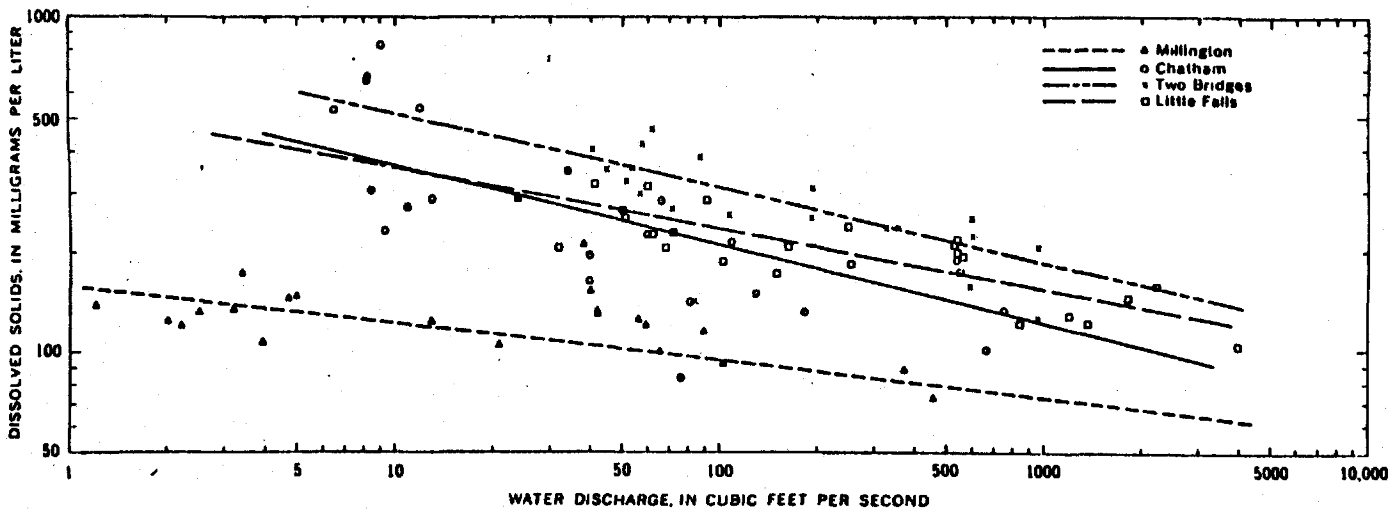


Figure 5. TDS versus Flow in Passaic River.

TDS_u = TDS concentration in the North Branch upstream of the EDC discharge, (mg/ℓ)

Q_u = flow rate in the North Branch upstream of the EDC discharge, (cfs)

TDS_E = TDS concentration in the EDC discharge, (mg/ℓ)

Q_E = flow rate of the EDC discharge, (cfs)

Application at the MA7CD10 and a treatment plant discharge rate of 0.85 mgd, requires Q_u = 6.3 cfs and Q_E = 1.31 cfs. Equation (17) specifies TDS_u = 170 mg/ℓ, and for maintenance of the 133% criterion TDS_d = 1.33 x 170 = 226. mg/ℓ. Solution of equation (18) for TDS_E gives an allowable discharge concentration of 500 mg/ℓ. When the outfall location was changed from the North Branch to the unnamed tributary, the 500 mg/ℓ effluent limitation was maintained as consistent with water quality standards and uses. It was determined that the net effect of discharge to the tributary would be positive in terms of impact to water quality in the North Branch. The continued receiving water quality monitoring program would be evaluated to ensure that standards and uses would continue to be met in both the North Branch and the tributary.

The impact associated with the proposed expansion can be calculated in a manner similar to equation (18).

$$TDS_d = \frac{(TDS_u \cdot Q_u) + (TDS_E \cdot Q_E) + (TDS_t \cdot Q_t)}{(Q_u + Q_E + Q_t)} \qquad (19)$$

where the subscripts u and d now refer to the North Branch upstream and downstream of the confluence with the tributary, and subscript t refers to the tributary. The Baseline Stream Monitoring Program indicates that average values for TDS_u are 122 mg/ℓ (range 72-171 mg/ℓ), consistent with equation (17). Therefore equation (17) is used to specify TDS_u for various values of Q_u. Average values for TDS_t were found to be 152 mg/ℓ (range 55-390 mg/ℓ) during the baseline monitoring program. Given this information it is possible to calculate TDS_d for values representative of the flow frequencies observed for Q_u and Q_t (Tables 5 and 4 respectively). This is demonstrated in Figure 6. Actual concentrations of TDS_d for various combinations of Q_u, Q_t, and Q_E are provided in Appendix III.

Figure 6 demonstrates that for all cases, the resulting TDS concentration in the North Branch is well below the 500 mg/ℓ standard. At an EDC discharge rate of 0.85 mgd, the 133% criterion is also met for all flow frequencies. The actual increase at the MA7DC10 is exactly 33% as discussed above. At an EDC discharge rate of 1.75 mgd, the 133% criterion (assuming average values for background concentrations) is predicted to be exceeded approximately ten percent of the time. The actual increase at the MA7CD10 is 58% (TDS_d = 269 mg/ℓ). Identical calculations at Q_E = 1.3 mgd predict the 133% criterion to be exceeded less than five percent of the time and an increase of 47% (TDS_d = 249 mg/ℓ) at the MA7CD10.

In light of these results, it is apparent that the definition of background concentrations is critical in requiring compliance with the 133% criterion. Regardless of the value chosen as background, no degradation of water uses is anticipated for two reasons. First, North Branch TDS concentrations are predicted to be less than 270 mg/ℓ even under the most critical conditions, i.e. MA7CD10 and Q_E = 1.75 mgd. This is well below the 500 mg/ℓ standard, and as an absolute value, has no impact on intended

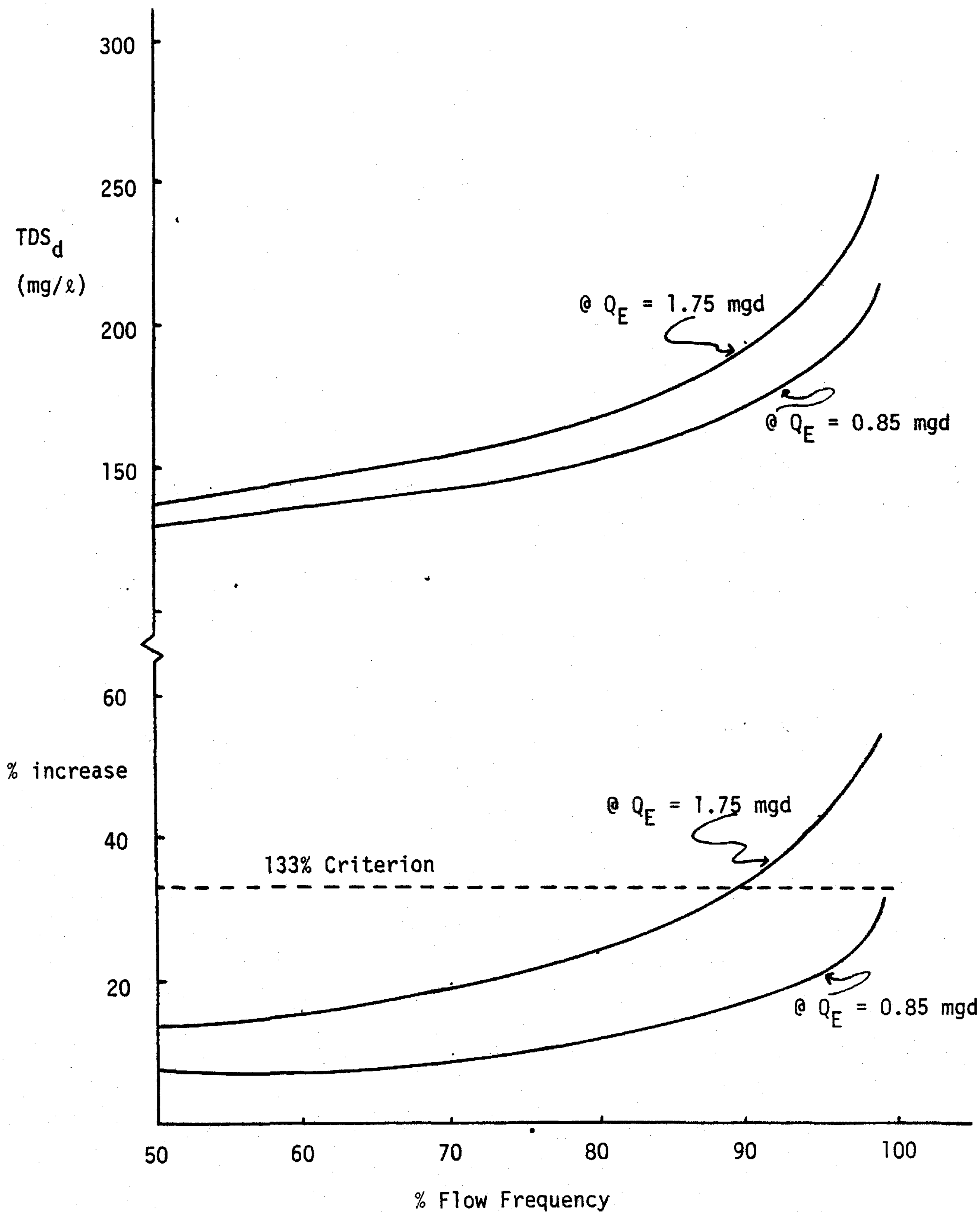


Figure 6. TDS_d-Flow Rate Relationship.

water uses. Second, gradual increases of TDS within reasonable limits over a number of years will probably not be harmful. The increase due to the EDC discharge will occur gradually over approximately ten to twelve years as development occurs. As a result there will not be a shock load causing a stress on aquatic organisms. It seems entirely plausible that these organisms could adapt to a gradual change in TDS concentration from 170 mg/ℓ to 270 mg/ℓ over a ten to twelve year period, considering that observed concentrations during a single eight month period revealed concentrations as high as 390 mg/ℓ. Furthermore, USEPA (1976) indicates that several common freshwater fish species survived 10,000 mg/ℓ dissolved solids. Indeed, it has been demonstrated above that even the calculated natural background concentration will, at low flow increase to 140% of that calculated under average flows.

Considering these facts and the costs of wastewater treatment to attain a TDS effluent limitation of less than 500 mg/ℓ, a waiver of the 133% criterion is warranted. To deny the waiver would be in direct conflict with Federal policies to attain cost-effectiveness in wastewater facilities planning. A prudent approach would be to maintain the 500 mg/ℓ effluent limitation and to continue receiving water quality monitoring. When the EDC wastewater flow rate begins to approach 0.85 mgd, a reevaluation of water quality impact could be made to determine the appropriate effleunt limitation for higher discharge flow rates. This is consistent with the current permit process since all permits are typically reviewed for renewal within five years of their initial date. That renewal date would probably occur at about the time the EDC facility will be treating a wastewater flow rate of 0.85 mgd.

2.5 Phosphorus

The analysis methodology for phosphorus is similar to that for total dissolved solids. The potential water quality impact however is quite different. Increased phosphorus loads can result in biostimulation and accelerated eutrophication. Background phosphorus concentrations in the tributary and upstream of the tributary in the North Branch Raritan are identified as 0.156 and 0.167 mg/ℓ respectively in the Baseline Stream Monitoring Program. The EDC effluent limitation is 0.5 mg/ℓ which represents state-of-the-art wastewater treatment.

FW2.N water quality standards specify that total phosphorus (as P) should not exceed 0.1 mg/ℓ in any stream where total phosphorus is determined to have a detrimental effect on stream use or to be the limiting factor. Existing concentrations in the North Branch Raritan already exceed the 0.1 mg/ℓ level, and stream uses have not been impaired. Therefore, it may be concluded that a total P greater than 0.1 mg/ℓ has not been determined to have a significant effect on stream use. There of course must be some limit to concentration above 0.1 mg/ℓ where total P will begin to have a detrimental effect on use. This limit will vary from one stream to the next depending on certain stream characteristics (e.g. flow rate, velocity, channel bed type) which determine its assimilative capacity. For the North Branch Raritan like many streams, this limit is not known. A reasonable approach would be to permit predicted increases to some percentage above the background concentration, and during the initial years of discharge conduct a stream water quality monitoring program to observe whether or not a detrimental limit is being approached. This is similar to the proposal recommended earlier for TDS. This information would then be available for incorporation in the permit review and renewal process.

Whether or not phosphorus is the limiting factor for eutrophication in the North Branch is not clear. During the warmer months of the year and because of the shallow depth of this stream, light availability is not a limiting factor. Similarly water temperatures are generally above 20°C during summer suggesting that this too is not a limiting factor. During winter of course, decreases in temperature and light strongly inhibit primary production. Trace elements (e.g. iron, zinc, etc.) are generally in plentiful supply in natural water systems like the North Branch, and as a result the limiting factor is generally the availability of nitrogen or phosphorus. Based on a typical algal cell composition of $C_{106}H_{263}O_{110}N_{16}P_1$, a stoichiometric molar ratio for $\frac{N}{P}$ of $\frac{16}{1}$ is demonstrated. On a weight or concentration basis the ratio is $\frac{7.2}{1}$. If the ratio in a stream is above this value, phosphorus is the limiting nutrient; if the ratio is below 7.2, nitrogen is limiting. From data in the Baseline Stream Monitoring Program, the ratio of total phosphorus to total nitrogen is $\frac{TN}{TP} = \frac{1.35}{0.167} = 8.1$ in the North Branch which is very close to the critical ratio. Given uncertainties in measurement error, it is impossible to say which of the two nutrients is limiting. Another indicator involves comparison of the inorganic fractions of nitrogen and phosphorus assuming it is only this portion and not the total concentration of the nutrient which is available for algal growth. The ratio of total inorganic nitrogen (i.e. ammonia-nitrogen plus nitrate-nitrogen) to total inorganic phosphorus (i.e. orthophosphate-phosphorus) is $\frac{TIN}{TIP} = \frac{1.10}{0.076} = 14.5$ suggesting that phosphorus is the limiting nutrient. The calculation of this number from the available data has one limitation in that TIP is probably under-estimated since the concentration of polyphosphate-phosphorus is not known. Therefore the ratio would be less than 14.5, bringing it closer to the critical ratio.

If phosphorus is assumed to be a conservative substance once discharged to the receiving water, then the resulting concentration in the North Branch will be:

$$TP_d = \frac{(TP_u \cdot Q_u) + (TP_E \cdot Q_E) + (TP_t \cdot Q_t)}{Q_u + Q_E + Q_t} \qquad (20)$$

where TP represents the phosphorus concentration in mg/ℓ, and all other terms are as defined previously.

The EDC design wastewater flow rate even at 0.85 mgd is significantly greater than the tributary flow rate. Therefore, it is anticipated that biological productivity will increase in the tributary. This was considered during the permit preparation stage with the understanding that this phenomenon actually has a positive effect in terms of water quality impact to the North Branch Raritan. It was generally agreed that discharge to the tributary is more desirable than a direct discharge to the North Branch, considering that the tributary would serve to decrease nutrient and other pollutant loads to the North Branch. The exact degree of reduction of the phosphorus load is not known à priori. However, data collected during the baseline monitoring indicate a reduction of nearly fifty percent for total phosphorus concentration from the point of the EDC discharge to the confluence with the North Branch. If this may be used as a first indicator of the load reduction to the North Branch, then equation (20) may be modified to:

$$TP_d = \frac{(TP_u \cdot Q_u) + 0.5[(TP_E \cdot Q_E) + (TP_t \cdot Q_t)]}{(Q_u + Q_E + Q_t)} \qquad (21)$$

At this time, we might consider equation (21) to provide an optimistic lower bound on expected value for TP_d, and equation (20) to provide a conservative upper bound for TP_d. The true value may lie somewhere between the two.

Figures 7 and 8 provide the solution of equations (20) and (21) respectively for various flow rates. Exact values are provided in Appendices IV and V. Considering that a direct discharge to the North Branch Raritan was originally permitted with Q_E = 0.85 mgd and TP_E = 0.5 mg/ℓ, then the water quality impact associated with these effluent limitations identifies an acceptable base-line condition subject of course to stream monitoring and demonstration of no adverse impact subsequent to initiation of the discharge. Figure 7 and Appendix IV demonstrate that at the MA7CD10, this scenario is predicted to result in a 34% increase in total phosphorus concentration above an average background concentration of 0.167 mg/ℓ. The ambient background TP concentration ranges between 0.035 and 0.374 mg/ℓ. At an EDC discharge rate of 1.75 mgd, a 34% increase results at the 95% frequency flow rate. In other words, less than 5% of the time predicted total phosphorus concentrations in the North Branch will exceed those originally permitted. This assumes that there is no phosphorus load reduction through natural self-purification processes in the tributary. For the case of a 50% load reduction due to the tributary (Figure 8 and Appendix V), the maximum predicted increase in TP_d is less than 15% regardless

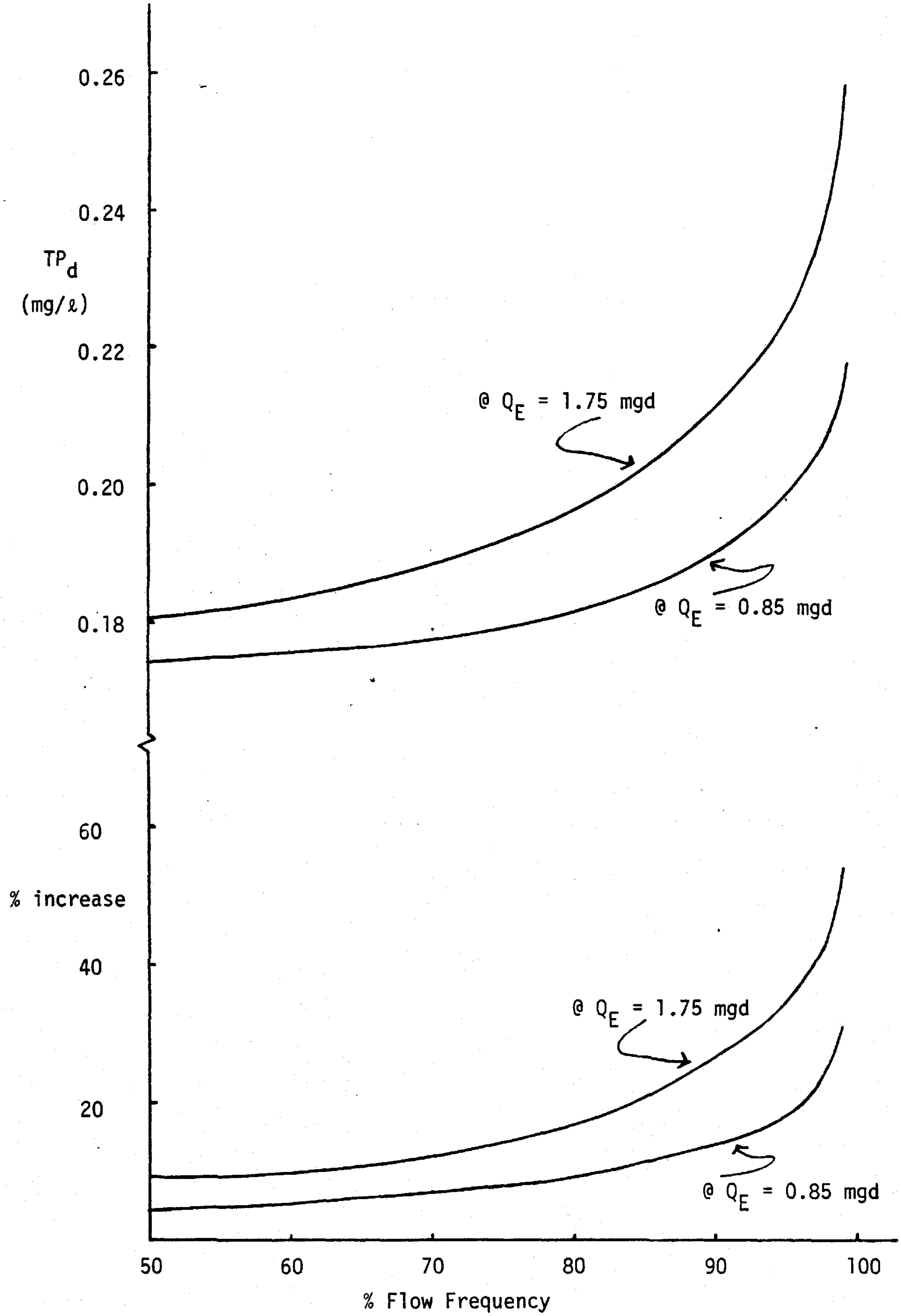


Figure 7. TP_d-Flow Rate Relationship (No Reduction in Tributary).

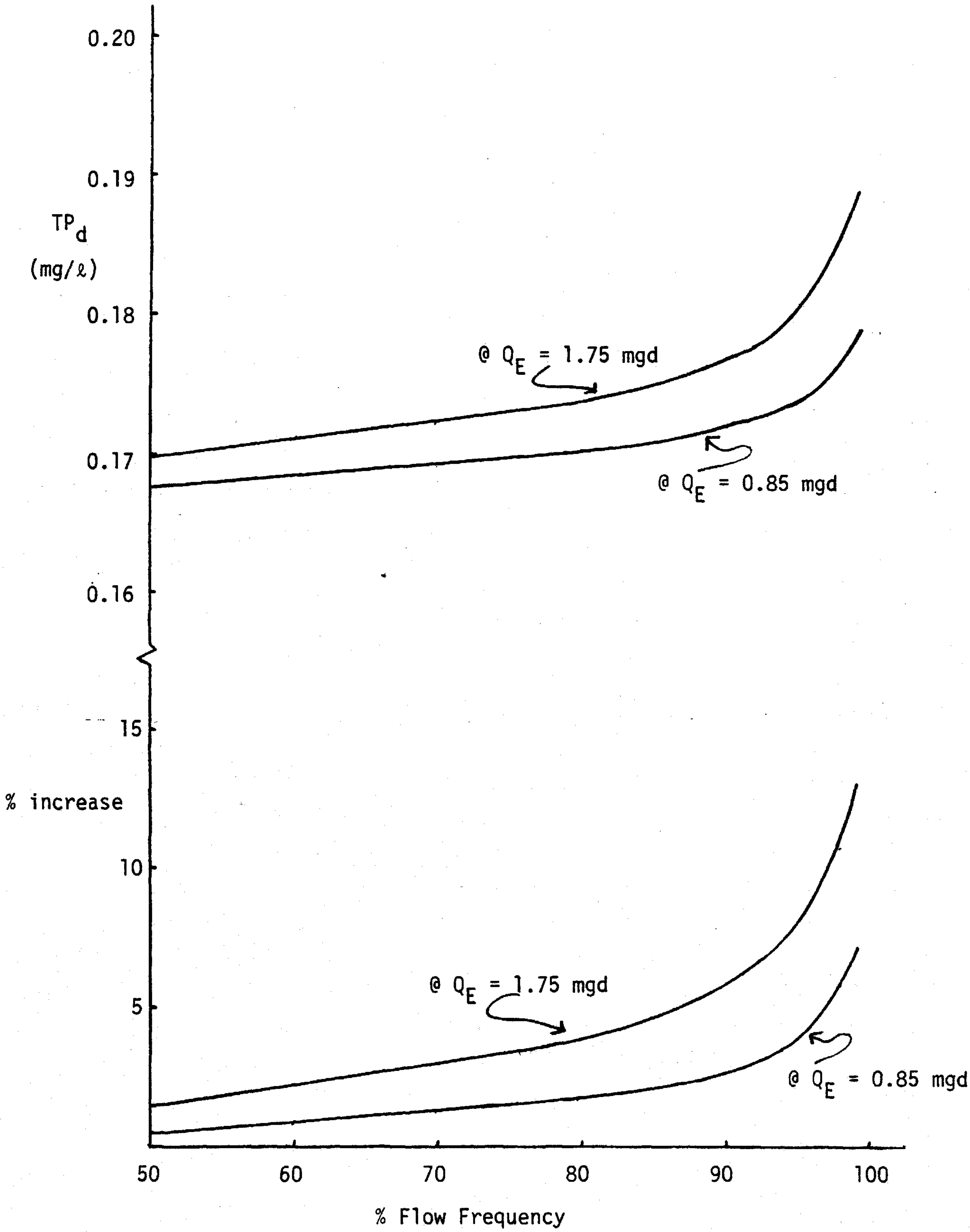


Figure 8. TP_d-Flow Rate Relationship (50% Reduction in Tributary).

of the EDC discharge rate up to 1.75 mgd suggesting little or no water quality impact.

The results of this analysis suggest that at very low flows (less than five percent of the time) and an EDC discharge rate of 1.75 mgd, TP increases in the North Branch Raritan River will exceed those originally permitted at an EDC discharge rate of 0.85 mgd if phosphorus is assumed to be a conservative substance. The increase may be significantly reduced below that theoretically predicted if natural self-purification processes in the tributary are instrumental in reducing the load to the North Branch. An initial review of the data suggest that the reduction is signficant. If this is the case, then an EDC discharge rate of 1.75 mgd and effluent total phosphorus concentration of 0.5 mg/ℓ would be acceptable. The recommended approach, again as with TDS, involves a stream monitoring program during the initial years of the treatment plant operation as discharge rate is gradually increased over several years to the currently permitted rate of 0.85 mgd. This data will enable a more accurate determination of (1) whether or not a detrimental effect to stream uses is associated with increases in total phosphorus, and (2) the degree of phosphorus load reduction to the North Branch through self-purification in the tributary.

2.6 Nitrogen

Increases in nitrogen, like phosphorus, can also lead to increased biostimulation and accelerated eutrophication. In addition, nitrogen in the unionized ammonia form, NH_3, can be toxic to aquatic organisms. Consequently there are two concerns with respect to an increased nitrogen loading rate. The following concentrations are available from the Baseline Stream Monitoring Program.

	NH_3-N	NO_3-N
Tributary upstream of confluence with North Branch	0.17	0.52
North Branch upstream of confluence with tributary	0.20	0.90

where NH_3-N = total (ionized plus unionized) ammonia nitrogen, and NO_3-N = nitrate nitrogen. FW2.N water quality standards specify (1) for nitrate-nitrogen "allowing for natural conditions, none which would render the waters unsuitable for the designated uses," and (2) for ammonia-nitrogen the "maximum concentration of unionized ammonia shall not exceed 50 μg/ℓ." The nitrate standard is rather nebulous but is concerned with two issues -- (1) public health for which potable waters must have a concentration for NO_3-N less than 10 mg/ℓ, and (2) eutrophication for which no absolute standard can be specified, but which will always be less than 10 mg/ℓ when considering surface waters. Therefore, the eutrophication issue is more critical. However, the allowable NO_3-N concentration in any stream is a function of its assimilative capacity as discussed above for phosphorus. Therefore, the philosophy of preventing any significant increase in concentration above natural background conditions must again be employed.

Effluent limitations for the EDC discharge are NH_3-N $\leq$ 0.5 mg/ℓ and NO_3-N $\leq$ 2.0 mg/ℓ. The analysis for eutrophication potential must be conducted for the sum of these two nitrogen species since both are available for algal uptake. If nitrogen is assumed to be a conservative substance then:

$$N_d = \frac{(N_u \cdot Q_u) + (N_E \cdot Q_E) + (N_t \cdot Q_t)}{(Q_u + Q_E + Q_t)} \qquad (22)$$

where N = NH_3-N + NO_3-N in mg/ℓ and all other terms are as defined previously. Solution of equation (22) is provided in Figure 9 and Appendix VI. These results assume there is no reduction of N through the tributary. Data from the baseline monitoring indicates an eleven percent reduction in NH_3-N + NO_3-N between the location of the EDC outfall and the confluence with the North Branch Raritan, far less than was observed for phosphorus. This is reasonable since NO_3-N, which is highly soluble, is the major portion of the total N considered here, and phosphorus is highly adsorptive and therefore more likely to be removed from the water column. Although there will be some reduction of the NH_3-N + NO_3-N load to the North Branch, it probably will not be very great particularly in contrast to the phosphorus reduction. Therefore, as a conservative measure, no reduction in load through the tributary will be assumed.

Inspection of the results in Figure 9 and Appendix VI reveal that under the originally permitted 0.85 mgd direct discharge to the North Branch Raritan, an increase of 22% results at the MA7CD10. At an EDC discharge rate of 1.75 mgd, this same increase is encountered at the 95% flow. Therefore less than 5% of the time, the percent increase will exceed 22%. The conclusions of this analysis are virtually identical to those for phosphorus, and therefore the recommended approach to setting effluent limitations is also identical. Stream monitoring should be conducted during the initial years of operation.

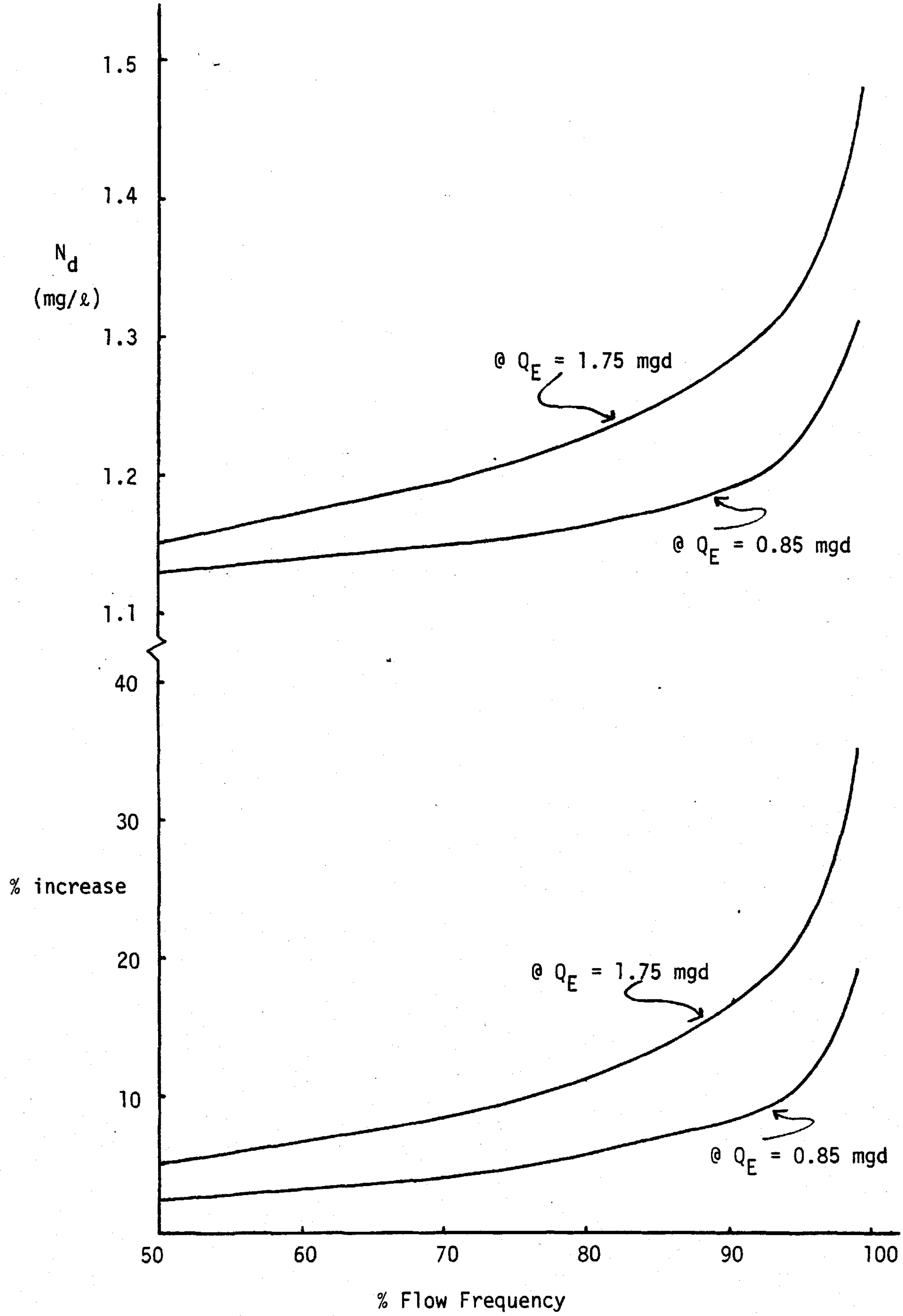


Figure 9. N_d-Flow Rate Relationship (No Reduction in Tributary).

As wastewater flow rates approach 0.85 mgd, an updated evaluation can be made to determine whether existing discharge quality will be acceptable at a flow rate of 1.75 mgd. If it is acceptable, then EDC can operate at the current effluent limitations and a flow rate of 1.75 mgd.

Analysis for the ammonia toxicity standard is straightforward. Given that the allowable unionized ammonia-nitrogen, $NH_3\text{-}N_g$, concentration must be less than 0.05 mg/ℓ, then the allowable total ammonia-nitrogen, $NH_3\text{-}N$, concentration in mg/ℓ is given as

$$NH_3\text{-}N = 0.05\left[1 + 10^{(pK_a - pH)}\right] \tag{23}$$

where $pK_a = 10.05 - 0.032\ T$

T = temperature, °C

$pH = -\log[H^+]$

For a critical temperature of 25°C and an average pH of 7.3 as identified in the baseline monitoring, then the allowable $NH_3\text{-}N$ concentration in the North Branch Raritan is 4.5 mg/ℓ. Even if a pH as high as 8.0 is assumed, the allowable $NH_3\text{-}N$ is 0.94 mg/ℓ. The resulting North Branch $NH_3\text{-}N$ concentration at any EDC discharge rate can be calculated via a mass balance

$$NH_3\text{-}N_d = \frac{(NH_3\text{-}N_u \cdot Q_u) + (NH_3\text{-}N_E \cdot Q_E) + (NH_3\text{-}N_t \cdot Q_t)}{(Q_u + Q_E + Q_t)} \tag{24}$$

For the most critical case of Q_E = 1.75 mgd and Q_u and Q_t at the MA7CD10, then $NH_3\text{-}N_d$ = 0.29 mg/ℓ. Since this value is well below the critical values computed above, then there will be no detrimental impact with respect to ammonia toxicity.

3. Conclusions and Recommendations

This study has been completed to assess receiving water quality impacts associated with expansion of the Environmental Disposal Corporation's Wastewater Treatment Facility. The treatment plant is currently permitted to discharge at a rate of 0.85 mgd. It is proposed that the capacity of the facility be increased to 1.75 mgd. The increase is required by recent court decrees which have substantially changed projected growth patterns within the EDC franchise area.

3.1 Conclusions

Total Dissolved Solids

•At the proposed discharge rate of 1.75 mgd, TDS concentrations in the North Branch Raritan River will continue to be well below the 500 mg/ℓ standard at all times. The EDC discharge rate will gradually increase over a period of 10 to 12 years as development occurs within the franchise area. For a growth rate of 0.15 mgd per year, the resulting TDS concentrations and percent increases are presented in Figures 10 and 11 respectively. At the MA7CD10, there will be approximately six years before receiving water concentration is predicted to reach a value of 133% of the ambient average concentration. At the 90% flow frequency, concentration is never predicted to exceed the 133% criterion. Within six years of operation, an ample receiving water data base will have been collected which can be used to reevaluate and refine the predictive techniques used in this study. Furthermore since the increases are demonstrated to be gradual, aquatic organisms are provided a substantial period of acclimation to these

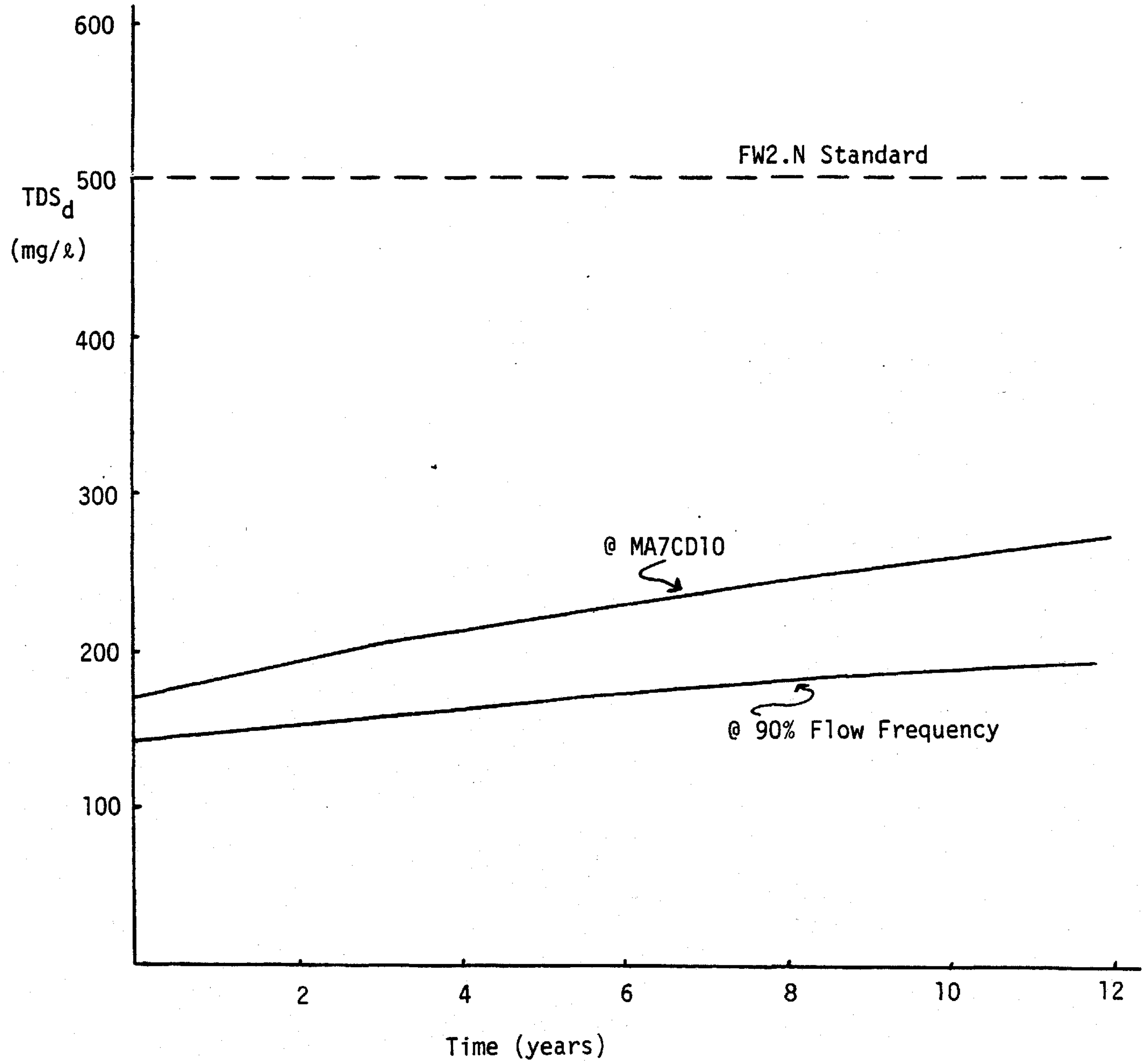


Figure 10. TDS_d Concentration-Time Relationship (Q_E = 1.75 mgd)

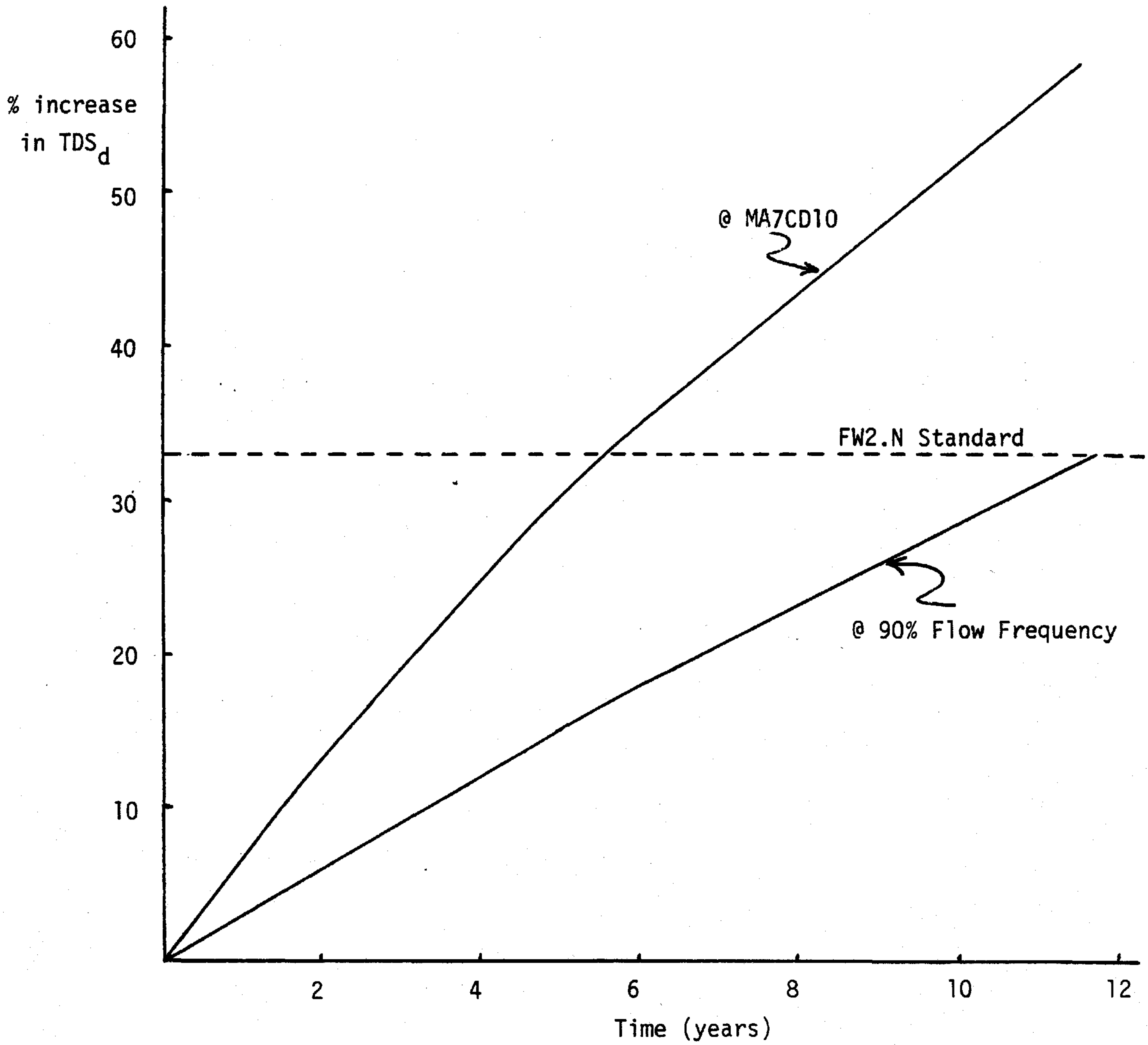


Figure 11. TDS_d % Increase-Time Relationship (Q_E = 1.75 mgd)

modest increases. However at the worst case, the maximum TDS concentration is only 270 mg/ℓ, a value which is clearly not detrimental to aquatic organisms indigenous to environments typical of the North Branch Raritan River. Currently observed concentrations were as high as 390 mg/ℓ during a single eight month period in 1983. Therefore, at an EDC discharge rate of 1.75 mgd and effluent TDS concentration of 500 mg/ℓ, no adverse impact to water quality is anticipated. The gradual increase accompanied by a water quality monitoring program provides a fail-safe system for confirmation and reevaluation of this conclusion.

Phosphorus

Analysis for phosphorus requires a determination as to whether or not an increase in loading will promote a detrimental effect on water use. The actual resulting concentration is not so important as the change in concentration above existing conditions. At the proposed wastewater flow of 1.75 mgd, effluent concentration of 0.5 mg/ℓ, and the MA7CD10 stream flow, North Branch phosphorus concentrations may increase 60% above existing conditions. Such an increase may stimulate primary production and accelerate eutrophication. However, the MA7CD10 occurs less than 1% of the time, and is not a valid flow criterion for evaluating eutrophication potential. Customarily the evaluation is made by looking at long term flow records. The data presented in Figure 6 predict a greater than 27% increase less than 10% of time. Whether or not this increase will accelerate eutrophication is questionable. Figure 12 shows the predicted percent increase over time at a growth rate of 0.15 mgd per year. Several years of operation and accompanying stream monitoring will occur before significant percent increases are encountered. This will allow ample time for reevaluation and refinement of the predictions made in this study. Furthermore, the results predicted in Figure 12 assume no reduction of the phosphorus load through the tributary. If a 50% reduction is observed as discussed above, then the maximum increase is 15% at the MA7CD10. No adverse impact is anticipated under these conditions.

Nitrogen

Ammonia toxicity is not a problem for this discharge. However, similar to phosphorus, analysis for nitrogen also requires a determination as to whether or not an increase in loading will promote a detrimental effect in terms of eutrophication potential. Again it is the percent increase above existing conditions which is important. At an EDC discharge rate of 1.75 mgd, effluent NH_3-N + NO_3-N concentration of 2.5 mg/ℓ, and the MA7CD10 stream flow, North Branch concentrations are predicted to increase 38% above existing conditions. Figure 9 predicts a greater than 17% increase less than 10% of the time. Therefore, the changes for nitrogen are predicted to be less than for phosphorus. Figure 13 demonstrates the projected increase over time. Again it will be a number of years before significant increases are encountered. In terms of eutrophication potential, phosphorus appears to be more critical than nitrogen.

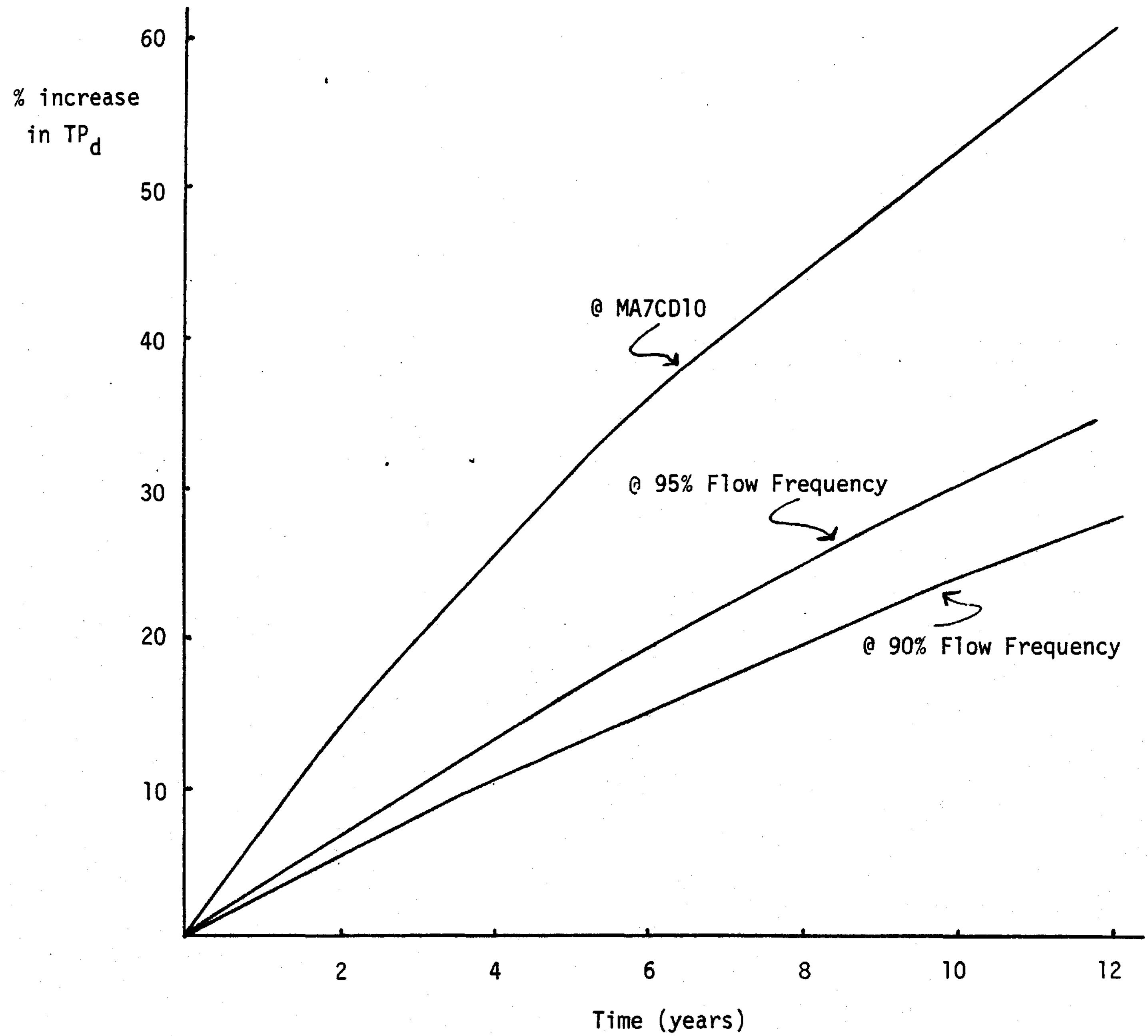


Figure 12. TP_d % Increase-Time Relationship (Q_E = 1.75 mgd)
(No Reduction in Tributary)

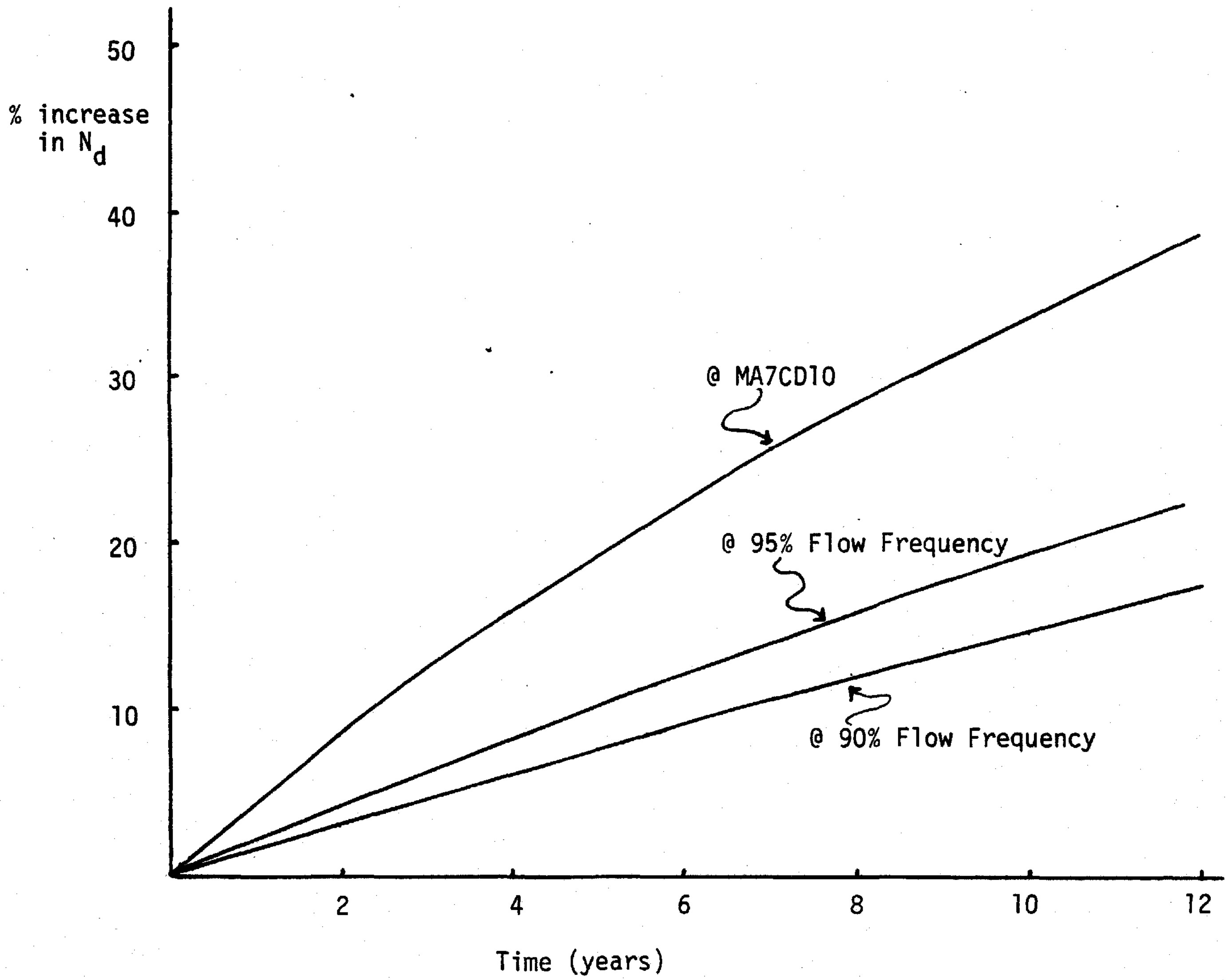


Figure 13. N_d % Increase - Time Relationship (Q_E = 1.75 mgd)
(No Reduction in Tributary)

3.2 Wastewater Treatment Options

Increase in wastewater flow rate from 0.85 mgd to 1.75 mgd will of course require expansion of treatment capacity at the existing facility. Meeting the current effluent limitations at the proposed flow rate can be satisfied through a combination of revised operation of the system and additional construction of unit processes similar to those currently in service. Flexibility in operation is provided through the capability to increase speed and submergence of aerators, vary sludge retention time, increase polymer and alum dosage, increase the frequency of filter backwash, etc. However, flows as high as 1.75 mgd could not be handled with the existing system even under a revised operation. A detailed design and reevaluation of current capacity must be undertaken to better identify the required facilities. But there is no question that a 1.75 mgd facility including unit processes similar to those in use at this time can be constructed to meet the current effluent limitations.

3.3 Recommendations

Given the conclusions regarding water quality impact, it is entirely realistic to permit expansion of the Environmental Disposal Corporation treatment facility to a capacity of 1.75 mgd. The current effluent limitations as presented in Table 1 can also be prescribed at the expanded capacity. A period of several years will pass before the EDC discharge rate will reach the currently permitted 0.85 mgd. A stream water quality monitoring program is imperative during this period. The information obtained will be invaluable in confirming whether or not any detrimental effect potentially exists at extremely low flows (i.e. less than five percent of the time) with a discharge rate of 1.75 mgd and the effluent limitations of Table 1. Reassessment and refinement of the predictive techniques used in this study should be completed periodically during the period of stream monitoring. Reassessment after three years and as the EDC discharge rate approaches 0.85 mgd is recommended.

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Appendix I

STREAM SOLUTION

STP Q AT 1.75 MGD: STREAM Q AT MA7CD10 (I.E. 0.03 & 6.3 CFS)

NUMBER OF SECTIONS
2

UPSTREAM CONDITIONS

FLOW =   0.CFS   CO =   8.4PPM   LO =   3.1 PPM   NC =   2.4 PPM

SECTION 1 PARAMETERS

FLOWS		LOADS		UPSTREAM CONDITIONS		REACTIONS		SOURCES/SINKS		OTHER PARAMETERS	
QO =	0.CFS	WC =	88.LBS	CO =	8.38PPM	KA =	8.40/DAY	PPM =	0.0	TEMP=	25.0
QA =	3.CFS	WL =	219.LBS	LO =	3.14PPM	KR =	0.70/DAY	RB =	0.0	FL =	1.0
QI =	3.CFS	WN =	33.LBS	NO =	2.42PPM	KN =	0.70/DAY	S =	0.0	FN =	1.0
						KD =	0.70/DAY			CS =	8.38

CONSTANT AREA SECTION

LENGTH = 0.6 MI DELTA = 0.1 MI AREA = 7.SQ.FT.

MILE PT.	DISSOLVED OXYGEN	OXYGEN DEFICIT	CARBONACEOUS BOD	NITROGENOUS BOD
0.0	6.02	2.36	14.85	2.29
0.05	6.07	2.31	14.74	2.27
0.10	6.13	2.25	14.64	2.26
0.15	6.17	2.21	14.54	2.24
0.20	6.22	2.16	14.44	2.22
0.25	6.27	2.11	14.34	2.21
0.30	6.31	2.07	14.24	2.19
0.35	6.35	2.03	14.14	2.18
0.40	6.38	2.00	14.04	2.16
0.45	6.42	1.96	13.94	2.15
0.50	6.45	1.93	13.84	2.13
0.55	6.49	1.89	13.75	2.12
0.60	6.52	1.86	13.65	2.10
0.65	6.55	1.83	13.56	2.09

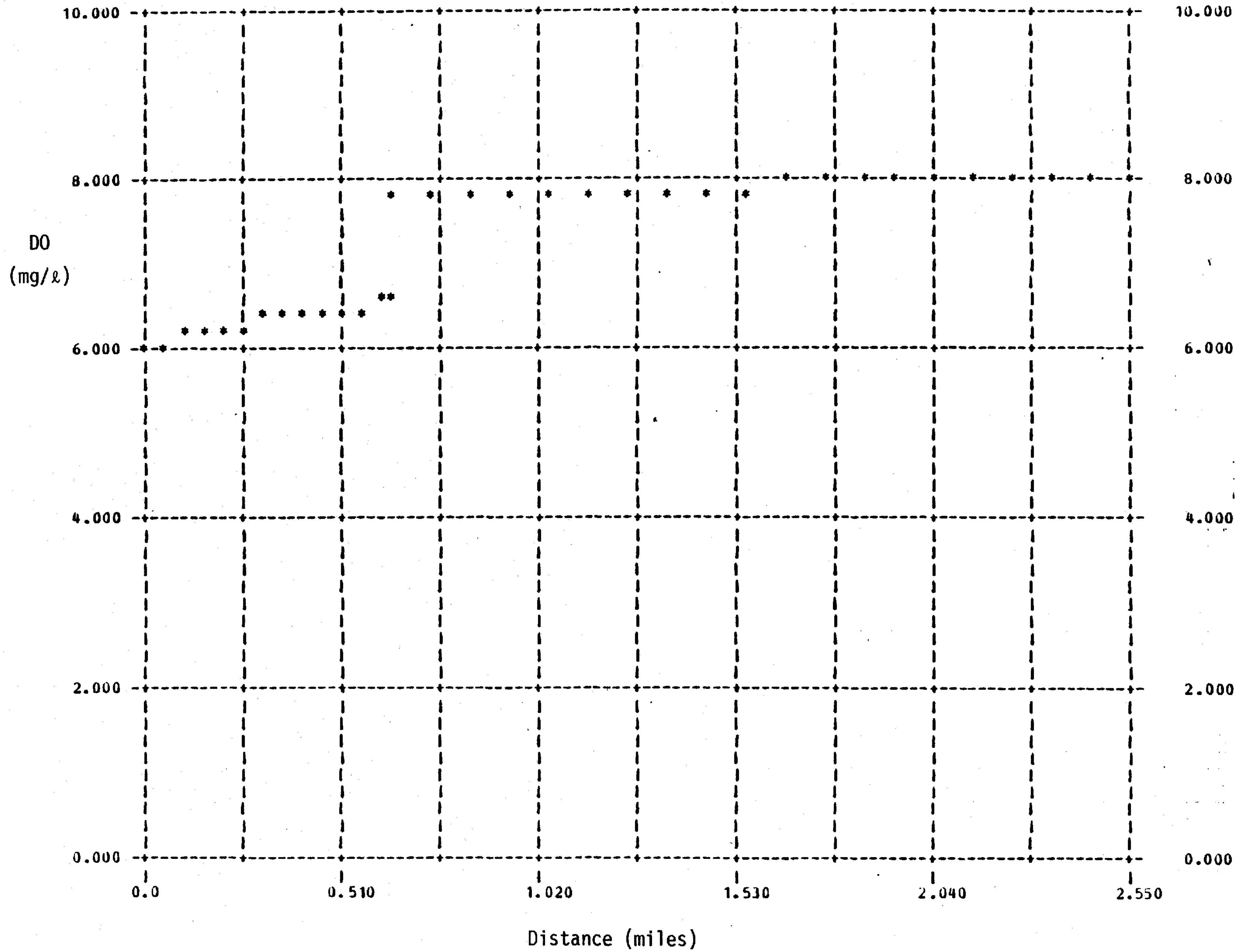
SECTION 2 PARAMETERS

FLOWS		LOADS		UPSTREAM CONDITIONS		REACTIONS		SOURCES/SINKS		OTHER PARAMETERS	
QO =	3.CFS	WC =	285.LBS	CO =	6.55PPM	KA =	12.54/DAY	PPM =	0.0	TEMP=	25.0
QA =	6.CFS	WL =	98.LBS	LO =	13.56PPM	KB =	0.80/DAY	BB =	0.0	FL =	1.0
QI =	9.CFS	WN =	70.LBS	NO =	2.09PPM	KN =	0.80/DAY	S =	0.0	FN =	1.0
						KD =	0.80/DAY			CS =	8.38

CONSTANT AREA SECTION

LENGTH = 1.9 MI   DELTA = 0.1 MI   AREA = 40.SQ.FT.

MILE PT.	DISSOLVED OXYGEN	OXYGEN DEFICIT	CARBONACEOUS BOD	NITROGENOUS BOD
0.65	7.81	0.57	6.11	2.07
0.75	7.81	0.57	5.95	2.01
0.85	7.81	0.57	5.79	1.96
0.95	7.82	0.56	5.64	1.91
1.05	7.83	0.55	5.49	1.86
1.15	7.84	0.54	5.34	1.81
1.25	7.85	0.53	5.20	1.76
1.35	7.86	0.52	5.06	1.71
1.45	7.88	0.50	4.93	1.67
1.55	7.89	0.49	4.80	1.62
1.65	7.90	0.48	4.67	1.58
1.75	7.91	0.47	4.55	1.54
1.85	7.93	0.45	4.43	1.50
1.95	7.94	0.44	4.31	1.46
2.05	7.95	0.43	4.20	1.42
2.15	7.96	0.42	4.09	1.38
2.25	7.97	0.41	3.98	1.35
2.35	7.98	0.40	3.87	1.31
2.45	7.99	0.39	3.77	1.28
2.55	8.00	0.38	3.67	1.24



10.000
8.000
6.000
4.000
2.000
0.000
DO
(mg/ℓ)
0.0
0.510
1.020
1.530
2.040
2.550
Distance (miles)

Appendix II

STREAM SOLUTION

STP Q AT 1.75 MGD: STREAM Q AT MA7CD10 (I.E. 0.03 & 6.3 CFS)

NUMBER OF SECTIONS
2

UPSTREAM CONDITIONS

FLOW =	0.CFS	CO	=	8.4PPM	LO	=	3.1 PPM	NO	=	2.4 PPM

SECTION 1 PARAMETERS

FLOWS		LOADS		UPSTREAM CONDITIONS		REACTIONS		SOURCES/SINKS		OTHER PARAMETERS	
QO =	0.CFS	WC =	88.LBS	CO =	8.38PPM	KA =	8.40/DAY	PPM =	0.0	TEMP=	25.0
QA =	3.CFS	WL =	219.LBS	LO =	3.14PPM	KR =	0.70/DAY	BR =	0.0	FL =	1.0
QI =	3.CFS	WN =	33.LBS	NO =	2.42PPM	KN =	0.70/DAY	S =	0.0	FN =	1.0
						KD =	0.70/DAY			CS =	8.38

CONSTANT AREA SECTION

LENGTH = 0.6 MI DELTA = 0.1 MI AREA = 7.SQ.FT.

MILE PT.	DISSOLVED OXYGEN	OXYGEN DEFICIT	CARBONACEOUS BOD	NITROGENOUS BOD
0.0	6.02	2.36	14.85	2.29
0.05	6.07	2.31	14.74	2.27
0.10	6.13	2.25	14.64	2.26
0.15	6.17	2.21	14.54	2.24
0.20	6.22	2.16	14.44	2.22
0.25	6.27	2.11	14.34	2.21
0.30	6.31	2.07	14.24	2.19
0.35	6.35	2.03	14.14	2.18
0.40	6.38	2.00	14.04	2.16
0.45	6.42	1.96	13.94	2.15
0.50	6.45	1.93	13.84	2.13
0.55	6.49	1.89	13.75	2.12
0.60	6.52	1.86	13.65	2.10
0.65	6.55	1.83	13.56	2.09

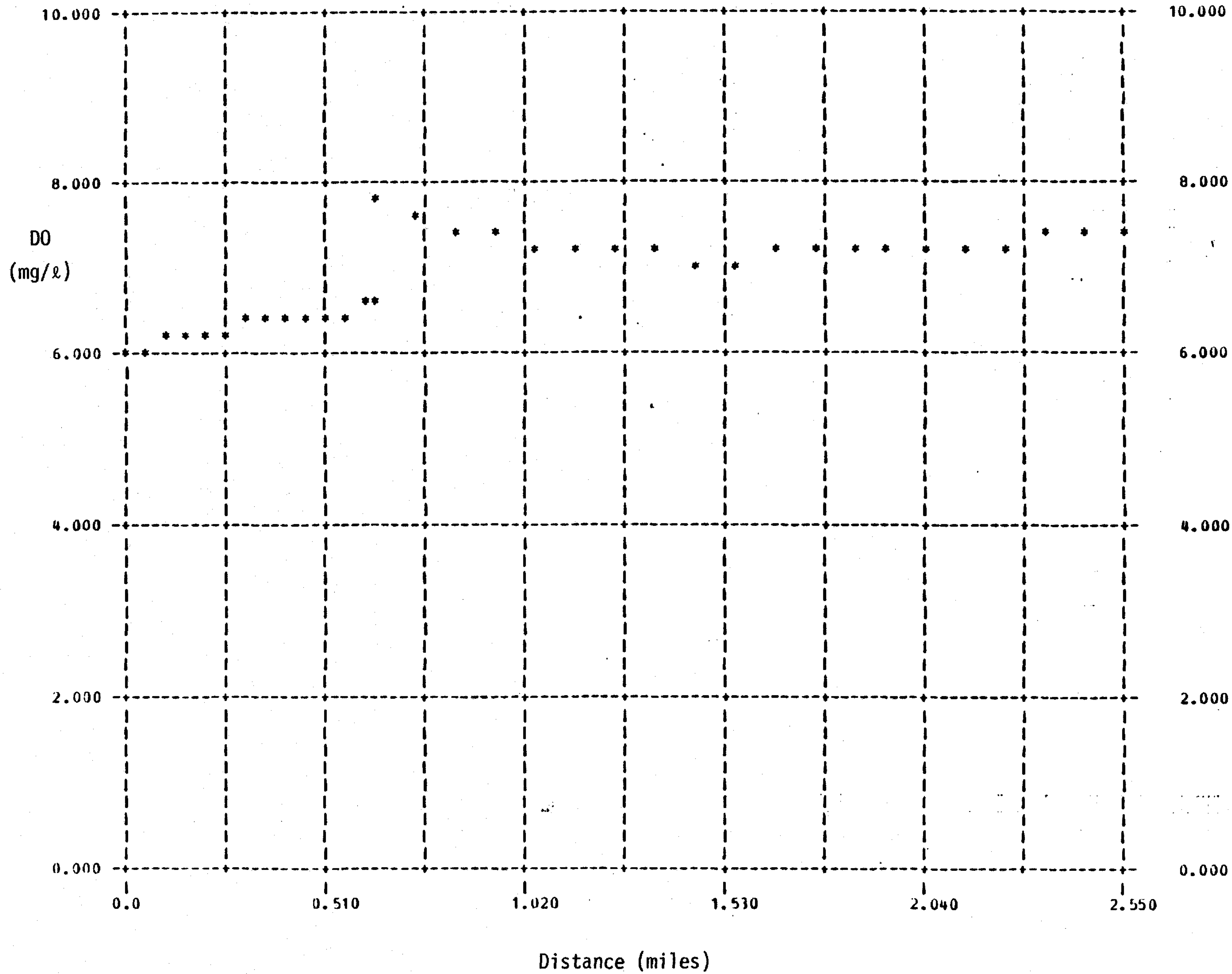
SECTION 2 PARAMETERS

FLOWS	LOADS	UPSTREAM CONDITIONS	REACTIONS	SOURCES/SINKS	OTHER PARAMETERS
QO = 3.CFS	WC = 285.LBS	CO = 6.55PPM	KA = 5.00/DAY	PEM = 0.0	TEMP= 25.0
QA = 6.CFS	WL = 98.LBS	LO = 13.56PPM	KR = 1.00/DAY	RR = 0.0	FL = 1.0
QI = 9.CFS	WN = 70.LBS	NO = 2.09PPM	KN = 1.00/DAY	S = 0.0	FN = 1.0
			KD = 1.00/DAY		CS = 8.38

CONSTANT AREA SECTION

LENGTH = 1.9 MI DELTA = 0.1 MI AREA = 50.SQ.FT.

MILE PT.	DISSOLVED OXYGEN	OXYGEN DEFICIT	CARBONACEOUS BOD	NITROGENOUS BOD
0.65	7.81	0.57	6.11	2.07
0.75	7.60	0.78	5.86	1.98
0.85	7.44	0.94	5.61	1.90
0.95	7.32	1.06	5.38	1.82
1.05	7.23	1.15	5.16	1.74
1.15	7.17	1.21	4.94	1.67
1.25	7.13	1.25	4.74	1.60
1.35	7.10	1.28	4.54	1.54
1.45	7.10	1.28	4.35	1.47
1.55	7.10	1.28	4.17	1.41
1.65	7.11	1.27	4.00	1.35
1.75	7.13	1.25	3.83	1.30
1.85	7.15	1.23	3.67	1.24
1.95	7.18	1.20	3.52	1.19
2.05	7.21	1.17	3.37	1.14
2.15	7.24	1.14	3.23	1.09
2.25	7.27	1.11	3.10	1.05
2.35	7.31	1.07	2.97	1.00
2.45	7.34	1.04	2.85	0.96
2.55	7.38	1.00	2.73	0.92


10.000
8.000
6.000
4.000
2.000
0.000
DO
(mg/ℓ)
0.0
0.510
1.020
1.530
2.040
2.550
Distance (miles)

Appendix III

TDS_d-Flow Rate Relationship*

Flow Frequency	Q_t(cfs)	Q_u(cfs)	TDS_d (% increase) @ Q_E = 1.75 mgd	1.3 mgd	0.85 mgd
MA7CD10	0.051	6.3	269(58)	249(47)	226(33)
99%	0.063	7.15	258(54)	239(43)	218(31)
98%	0.091	9.21	237(48)	221(38)	202(26)
95%	0.12	12.8	213(39)	199(31)	185(21)
90%	0.16	17.2	194(33)	183(25)	171(17)
80%	0.25	27.9	168(24)	160(18)	152(12)
70%	0.36	35.4	152(20)	151(15)	144(10)
60%	0.49	47.2	146(16)	141(12)	136(8.2)
50%	0.62	58.4	138(14)	134(11)	130(7.0)

*TDS_d in mg/ℓ

$TDS_u = 225\ Q_u^{-0.152}$ mg/ℓ

$TDS_t = 152$ mg/ℓ

$TDS_E = 500$ mg/ℓ

Appendix IV

TP_d-Flow Rate Relationship*

(No Reduction in Tributary)

Flow Frequency	Q_t(cfs)	Q_u(cfs)	TP_d (% increase) @ Q_E = 1.75 mgd	1.3 mgd	0.85 mgd
MA7CD10	0.051	6.3	0.226(60)	0.247(48)	0.224(34)
99%	0.063	7.15	0.258(54)	0.240(43)	0.218(31)
98%	0.091	9.21	0.242(45)	0.226(35)	0.208(25)
95%	0.12	12.8	0.225(34)	0.212(27)	0.198(18)
90%	0.16	17.2	0.212(27)	0.201(21)	0.190(14)
80%	0.25	27.9	0.196(17)	0.189(13.3)	0.182(8.8)
70%	0.36	35.4	0.190(14)	0.185(10.5)	0.179(7.0)
60%	0.49	47.2	0.185(10.6)	0.180(8.0)	0.176(5.3)
50%	0.62	58.4	0.181(8.7)	0.178(6.5)	0.174(4.3)

*TP_d in mg/ℓ

TP_u = 0.167 mg/ℓ

TP_t = 0.156 mg/ℓ

TP_E = 0.5 mg/ℓ

Appendix V

TP_d-Flow Rate Relationship*

(50% Reduction in Tributary)

Flow Frequency	Q_t(cfs)	Q_u(cfs)	TP_d (% increase) @ Q_E = 1.75 mgd	1.3 mgd	0.85 mgd
MA7CD10	0.051	6.3	0.191(14.6)	0.186(11.6)	0.181(8.1)
99%	0.063	7.15	0.189(13.2)	0.184(10.5)	0.179(7.2)
98%	0.091	9.21	0.185(10.8)	0.181(8.4)	0.176(5.7)
95%	0.12	12.8	0.181(8.2)	0.177(6.3)	0.174(4.1)
90%	0.16	17.2	0.177(6.3)	0.175(4.7)	0.172(3.0)
80%	0.25	27.9	0.174(3.9)	0.172(2.9)	0.170(1.8)
70%	0.36	35.4	0.172(3.0)	0.171(2.1)	0.169(1.2)
60%	0.49	47.2	0.171(2.2)	0.169(1.5)	0.168(0.8)
50%	0.62	58.4	0.170(1.6)	0.169(1.1)	0.168(0.5)

*TP_d in mg/ℓ

TP_u = 0.167 mg/ℓ

TP_t = 0.156 mg/ℓ

TP_E = 0.5 mg/ℓ

Appendix VI

N_d-Flow Rate Relationship*

(No Reduction in Tributary)

Flow Frequency	Q_t(cfs)	Q_u(cfs)	N_d (% increase) @ Q_E =		
			1.75 mgd	1.3 mgd	0.85 mgd
MA7CD10	0.051	6.3	1.52(38)	1.43(30)	1.34(22)
99%	0.063	7.15	1.48(35)	1.40(28)	1.31(19)
98%	0.091	9.21	1.41(28)	1.35(22)	1.27(15)
95%	0.12	]2.8	1.34(22)	1.29(17)	1.23(11)
90%	0.16	17.2	1.29(17)	1.24(13)	1.19(8.6)
80%	0.25	27.9	1.22(10.9)	1.19(8.2)	1.16(5.4)
70%	0.36	35.4	1.19(8.6)	1.17(6.4)	1.15(4.1)
60%	0.49	47.2	1.17(6.5)	1.15(4.8)	1.13(3.0)
50%	0.62	58.4	1.16(5.2)	1.14(3.8)	1.13(2.4)

*N_d in mg/ℓ

N_u = 1.1 mg/ℓ

N_t = 0.69 mg/ℓ

N_E = 2.5 mg/ℓ